[2019-
2020]

[PV cleaning system]

Lead to high Efficiency >>

[Graduation project in EAEAT academy our purpose from this system is leading to high efficiency in solar panels by reducing reasons of wasting and consumption of power]

[August]
[2020]

Egyptian Academy for Engineering & Advanced Technology

Graduation Project (2)

PV Cleaning System

Project Code: MEC 492

Technical Report

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We present all thanking and Appreciation to **Academy of Scientific Research and Technology** for funding us in our graduation project and support us to end our project PV cleaning system

Abstract

This project aims to design an automated solar panel cleaner system which can avoid the bad impact of soiling on PV solar panel cells in order to reduce the loss and annual consumption of power energy up to 10% .

Many studies that focused on the transparency performance of solar panel PV systems investigated that about 18% reduction of energy output was observed when working up to eight months and an increase in energy output reduction occurred by increasing the period to a year. Thus the need for increasing the light transferred to the panel and raising the energy output is an important demand.

In this work, an automated solar panel PV cleaning system was designed and manufactured. Practical results showed that Using automated system to clean solar panels to save labor and the annual continuous cost because the automatic system works for large periods of time up to 10 years without additional cost

The efficient system of the automatic system provided a lot of waste solar energy as a result of the accumulation of dust and impurities that are difficult to slip, as the solar energy that is saved reached from 18% to 40% depending on the nature of the climate

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Key Word

PV	Photovoltaic

Chapter 1

Introduction

Chapter 1: Introduction

Renewable energy resources are of great importance in the development high technology applications

Developing history of PV automated cleaning system classify that There were fewer than 10 articles per year on the impact of dust on solar power generation before 2009 .There were more than 80 articles in 2015. It was noted that the loss of power generation due to dust accumulation exceeds 40 % exposure to dust Annual losses in energy production due to dust deposition could be 10% with weekly cleaning.[1]

The **main objective** of Automated solar panel cleaning formed in solving the problem of Dirt which can be in the form of dust, pollen, paper, and waste birds which can accumulate on the surface of photovoltaic panels. so, cleaning solar panels is necessary to ensure optimum performance and maximum power production

Problem statement to increase the efficiency of the PV system Because The dirt of PV modules in this dust-prone area is a big problem because it can reduce the amount of energy and even reduce the life of panels and other components in the photovoltaic system. [3]

in the first place there are several ways to clean each solar panel with its advantages and disadvantages. The choice of the ideal method, which would improve the energy efficiency of the PV plant in the light of its economic and environmental requirements and can be formed and after we explain some different cleaning methods [3]

Due to the accumulation of dust on photovoltaic panels, the amount of solar radiation falling on the surface decreases in value and thus the efficiency of photovoltaic panels decreases over time. Scientists have done a lot of tests and found that due to dust, sand and dirt. And A significant decrease in the outside power has been observed that were in very large difference when cleaning is induced for photovoltaic panels. As shown in figure [9]

the accumulation of dust or other dirt on the(Soiling panels) phenomenon of accumulation of solar dirt that requires cleaning the panels to remove them Global losses due to this phenomenon in 2018 were estimated from 3-5 billion dollars

Some of PV cleaning systems have undesired side effects and not be suitable in some circumstances and situations like when it need existing of labors and high cost

so we need to use the best manner and type of cleaning system to avoid these disadvantages [10] dirt can have a significant impact on reducing and cutting external energy even in areas with heavy rainfall. Therefore, the methods of cleaning the photovoltaic panels were classified as follows

1) Natural Cleaning

2) Manual Cleaning

3) Water spray Helotes technology

4) vehicle cleaning systems on a truck

5) fully Automatic cleaning systems

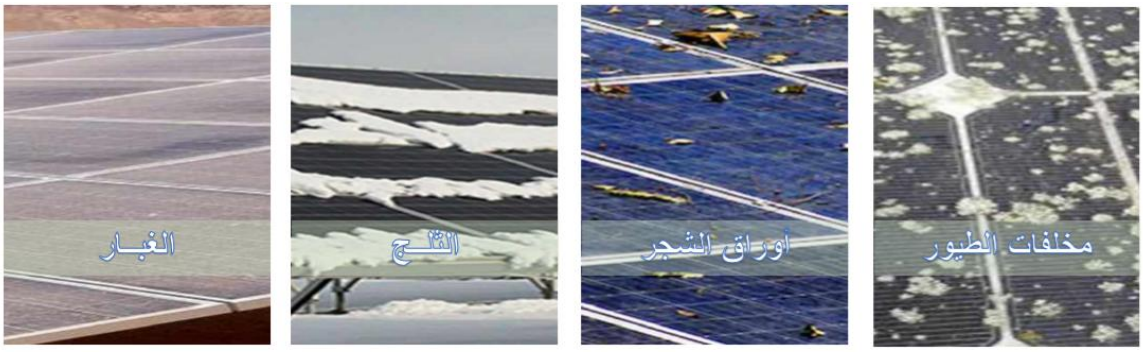


Fig 1-1 : Example of Dust

1) Natural Cleaning

Sufficient rainfall can provide free cleaning of PV modules. However, seasonal variability makes rain an unreliable cleaning source, especially when soiling is intensive and rainfall is not enough to thoroughly clean the modules. As mentioned in (Kimber. 2006), sharp declines in performance have been observed in some cases after a light rainfall. Wind can also reduce soiling from leaves and dust but only to a certain degree after which water is needed to clean the module from any residue. [11]

Advantages:-

Provide free cleaning of PV modules.

disadvantages:-

Rainfall is not enough to thoroughly clean the modules.

2) Manual Cleaning

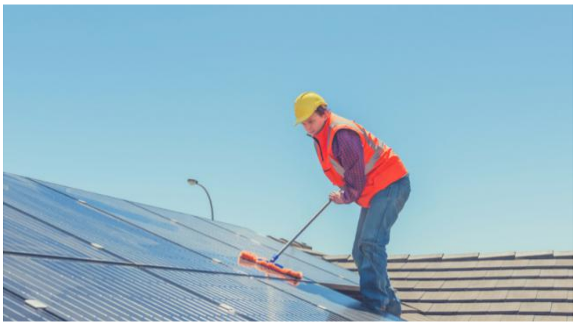


Fig 1-2 : Manual cleaning

This cleaning method is similar to the way in which companies' windows are cleaned.

The cleaning is done using a special bristle mattress specially designed to prevent any scratching on the photovoltaic panels. The mattresses can also be connected to water for washing and cleaning at the same time. But you may need to prepare, you may need a ladder and a long-handed brush so that we can reach as far as possible, and also this way of cleaning needs a man power [12]

Advantages:-

Cleaning only when required

easy to use.

usable for distress area

no need for control system.

very low maintenance.

disadvantages:-

Cost varies subjected to location and manpower. Consumption water

highly Need human all the time. , Not usable for large farms.

Not reachable for all modules ,Time consuming and ineffective

3) Water spray Helotes technology:

The system can be used for cleaning if we want to wash thoroughly and frequently in the day. This operating principle is similar to that used on golf courses. It is very good in quick cleaning times and does not require a lot of labor but it needs to be made a periodic maintenance sediment filter. It also consumes a lot of water. [13]

Advantages:-

Water reaches to every part of Solar PV modules

Helps in cooling of Solar PV modules, which increases the efficiency

The system is not complex.

Easy to control and usable ,We can add soap for biter clean.

disadvantages:-

Treated water required

Filter has to be change periodically.

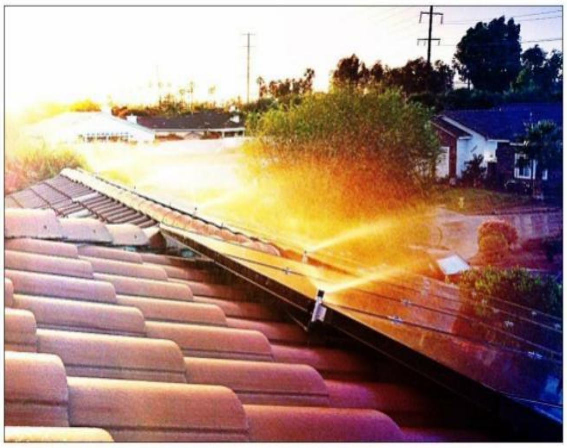


Fig 1-3 : Water spray Helotes technology

Huge wastage of water and Water consumption is very high and high initial cost

4) Vehicle cleaning systems on a truck

Composed of a small truck mounted on a large brush and driven by tracks between the rows of solar panels.

At least one operator is sufficient for this system, and it must be well trained to control the truck well and properly. To be able to use this system in cleaning must be installed panels in rows to allow the passage of the truck and often ranging between (2.5 to 3m) In addition must leave a distance at the end of each row in order for the truck to wrap and must be panels at an angle of Milan allows the application of this technique. Care must be taken when using this technique because it carries several dangers on the boards, whether the weight of the brush or the device as a whole or form the way in front of the plates as The presence of pits may lead to obstruction of the movement of the truck [13]

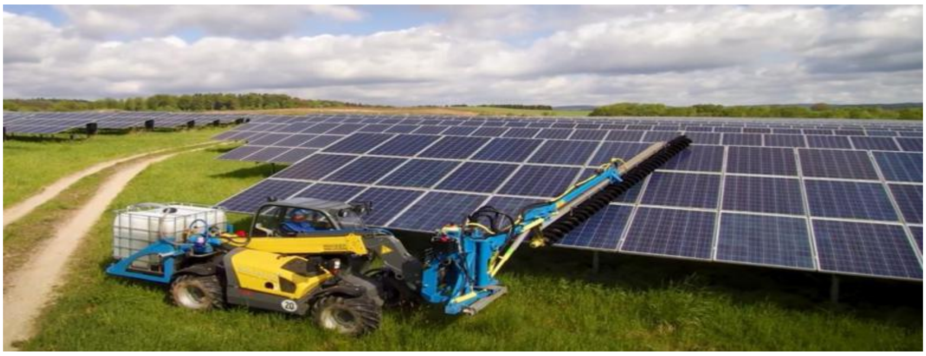


Fig 1-4 : Vehicle cleaning systems on a truck

5) Fully Automatic cleaning systems:

Full automatic cleaning device is dedicated to cleaning the complete panels by one device only goes to the end of the row and then due to the existence of sensors at the end of the row and move to the second row automatically and this device is characterized by it reduces the cost of workers so that there is no one to carry this device.

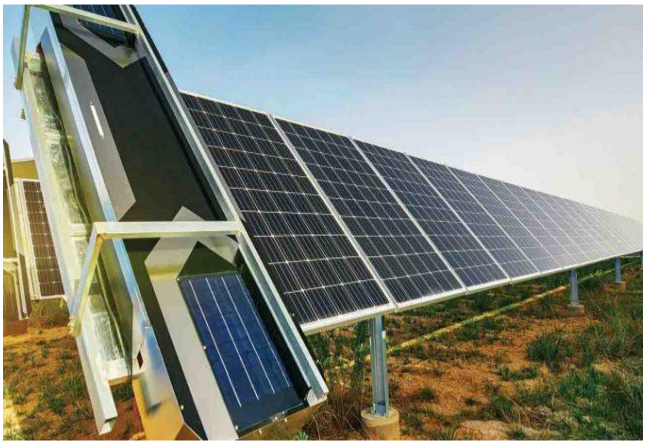


Fig 1-5 : Fully Automatic cleaning systems

Advantages:-

Full automated and

don't need employee

disadvantages:-

Initial cost is high

Heavy weight

[13]

Important directions during the cleaning process:-

It is advised to clean the solar panels at the beginning or end of the day

- Observe all safety instructions from manufacturers of solar panels

Pay close attention to cleaning the edges and corners

It is recommended to use simple cleaning materials such as fabrics

- Performance must be monitored permanently and deal with any problem affecting it directly and quickly

- Do not walk or rest on solar panels or metal frame during cleaning operations, so as not to cause cracks.

- Do not use any metal or sharp objects when cleaning the solar panel

- No chemicals should be used without consulting the manufacturer, as this may damage the paint on the solar panels.

-Use lukewarm water when cleaning, as it is important to avoid cold or hot water, as this will cause cracking

-The water should be clean

-Water pressure should not exceed 6 bar

-Access to water, electrical cables, and the junction box should be avoided

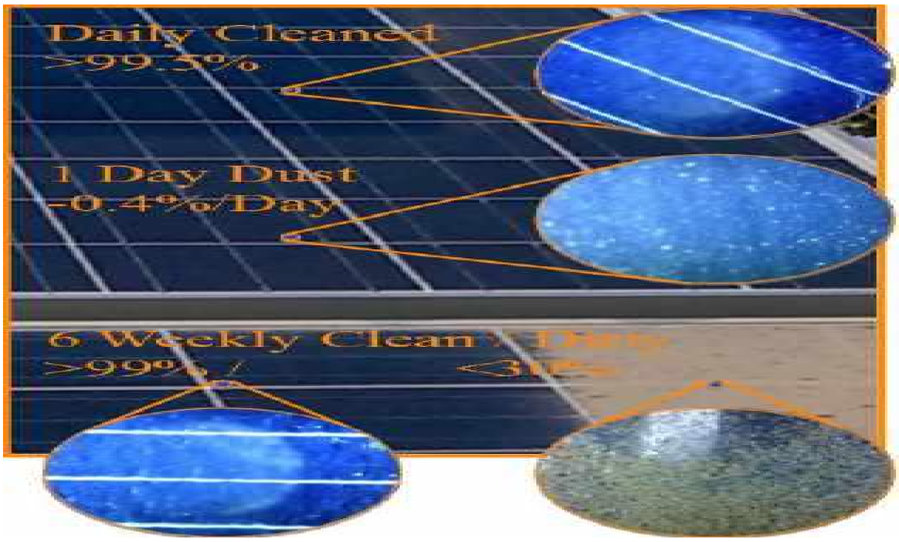


Fig 1-6 : General considerations for dust

Chapter 2

Problem Statement

Chapter 2 : Problem Statement

The **problems** in outdoor installed PV modules efficiency may reduce by 10% to 40%. The reduction in the performances, and dust pollution and Any substance spreads in the air includes soil and dust particles (suspended dust), smoke, fog and particulate matters general dust, sand, moss and dirt that does not wash off with just rain. This reduces the amount of light hitting the panel and reduces its output it is important to clean solar panels in order to protect and maintain your investment [2]

we will look for problems that affect solar radiation and solar panels solar energy.

Sun-Tracking loss:

while the solar panel is usually fixed at an angle to the horizontal plane. Therefore, a lot of radiation energy can be wasted due to unmatched direction. To maximize solar efficiency, a tracker is needed. [6]

Shading loss:

Only shading occurs when the solar system is shaded by trees, buildings or organisms near the area. The loss of shading on the panels is on the way if the panels are located in a place far from the buildings [7]

Soiling loss:

Soiling loss means the loss in PV system caused by snow, dirt, dust or some other particles that block the surface of PV system from irradiation absorption. [8]

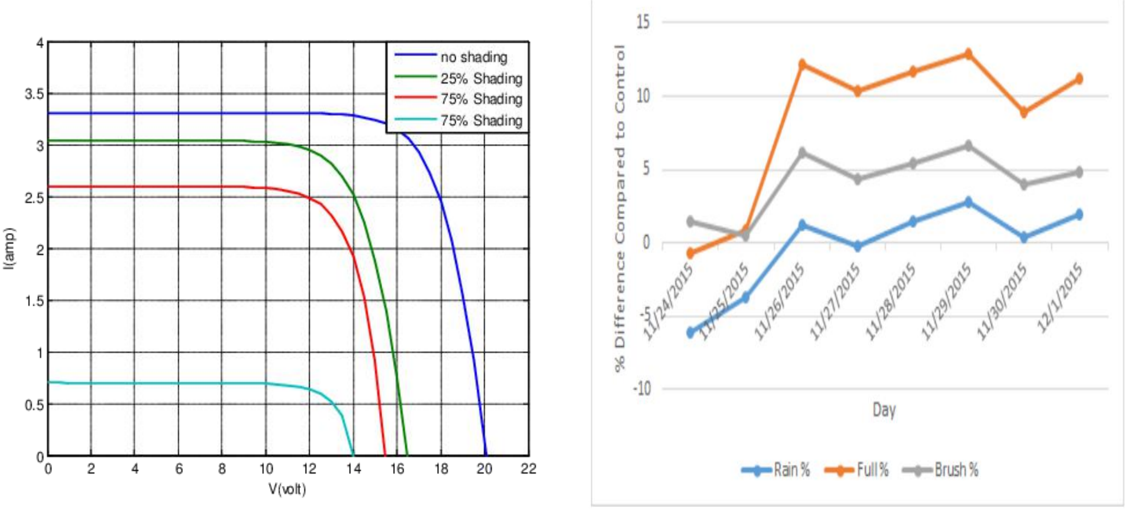
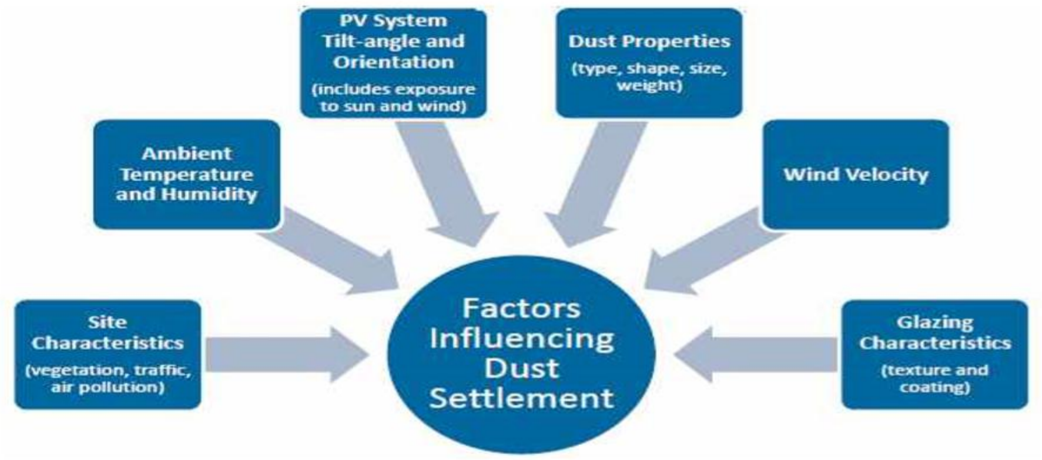


Fig 2-1 : shading loss and types of cleaning system

The effect of dust accumulation on the solar panels

Up to 30% per month	←	Reducing panels productivity
Up x 3	←	Increased maintenance and cleaning costs
Hotspots	←	Increased percentage of defects and malfunctions

Several factors play a role determin ining the rate of dust


PV System
Tilt-angle and Orientation
(includes exposure to sun and wind)
Dust Properties
(type, shape, size, weight)
Ambient Temperature and Humidity
Wind Velocity
Site Characteristics
(vegetation, traffic, air pollution)
Factors Influencing Dust Settlement
Glazing Characteristics
(texture and coating)

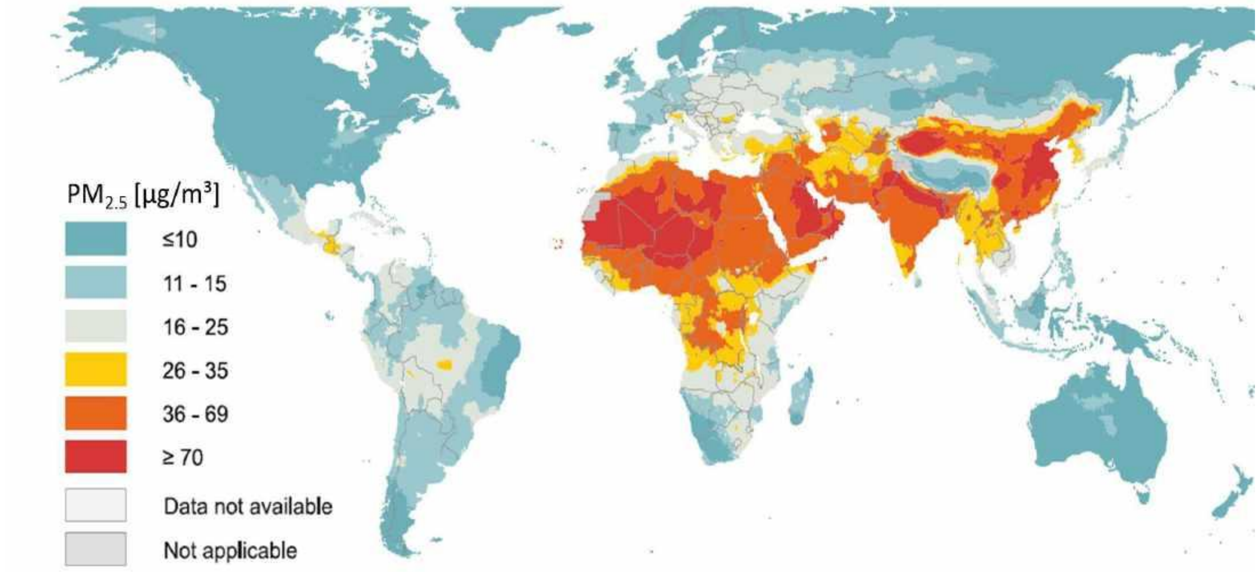
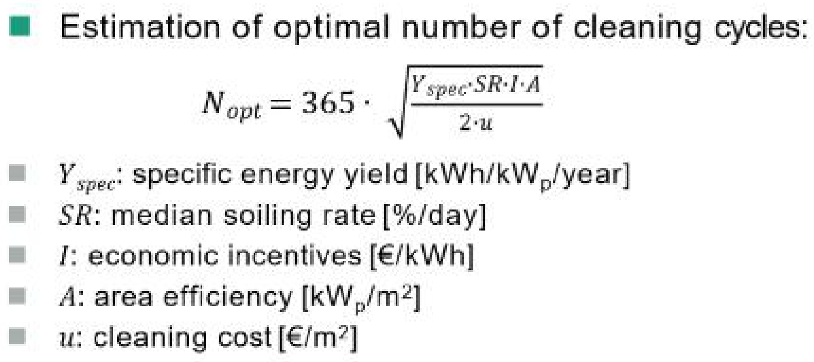


Fig 2-2 : Global dust belt

How to calculate the number of cleaning times required per year



- Estimation of optimal number of cleaning cycles:

$$N_{opt} = 365 \cdot \sqrt{\frac{Y_{spec} \cdot SR \cdot I \cdot A}{2 \cdot u}}$$

- Y_{spec}: specific energy yield [kWh/kW$_p$/year]
- SR: median soiling rate [%/day]
- I: economic incentives [€/kWh]
- A: area efficiency [kW$_p$/m^2]
- u: cleaning cost [€/m^2]

$$soiling\ costs = financial\ losses + cleaning\ costs$$

The problem which faced us within execute the project:-

1. There are problems that we faced during the implementation of the project through our need for more than one workshop to implement the various manufacturing works such as turning, drilling, welding and draining, and the lack of one workshop or one place that includes providing all manufacturing capabilities
2. We also had difficulty in the distance between the places of purchase and the places of manufacturing operations
3. The other problems with the designs that we have made are that the selection of materials and motor designs is not appropriate with the materials and motor available in the market in terms of sizes and capacities, as we faced problems in finding motors with high capacities and sizes
4. We also found problems during 3D printing, as we did not find the material that we designed to print from plastic A B S , which led to its replacement with plastic B A material and its printing
5. We had difficulties with aluminum welding and resolved them by using suitable aluminum welding patterns as Arc Welding Processes
6. Not existence suitable pump in market appropriate with the flow of water which designed to push water to clean solar panels so we decided to put pump system near attached with cleaning carriage

Chapter 3

Project Goals and Deliverables

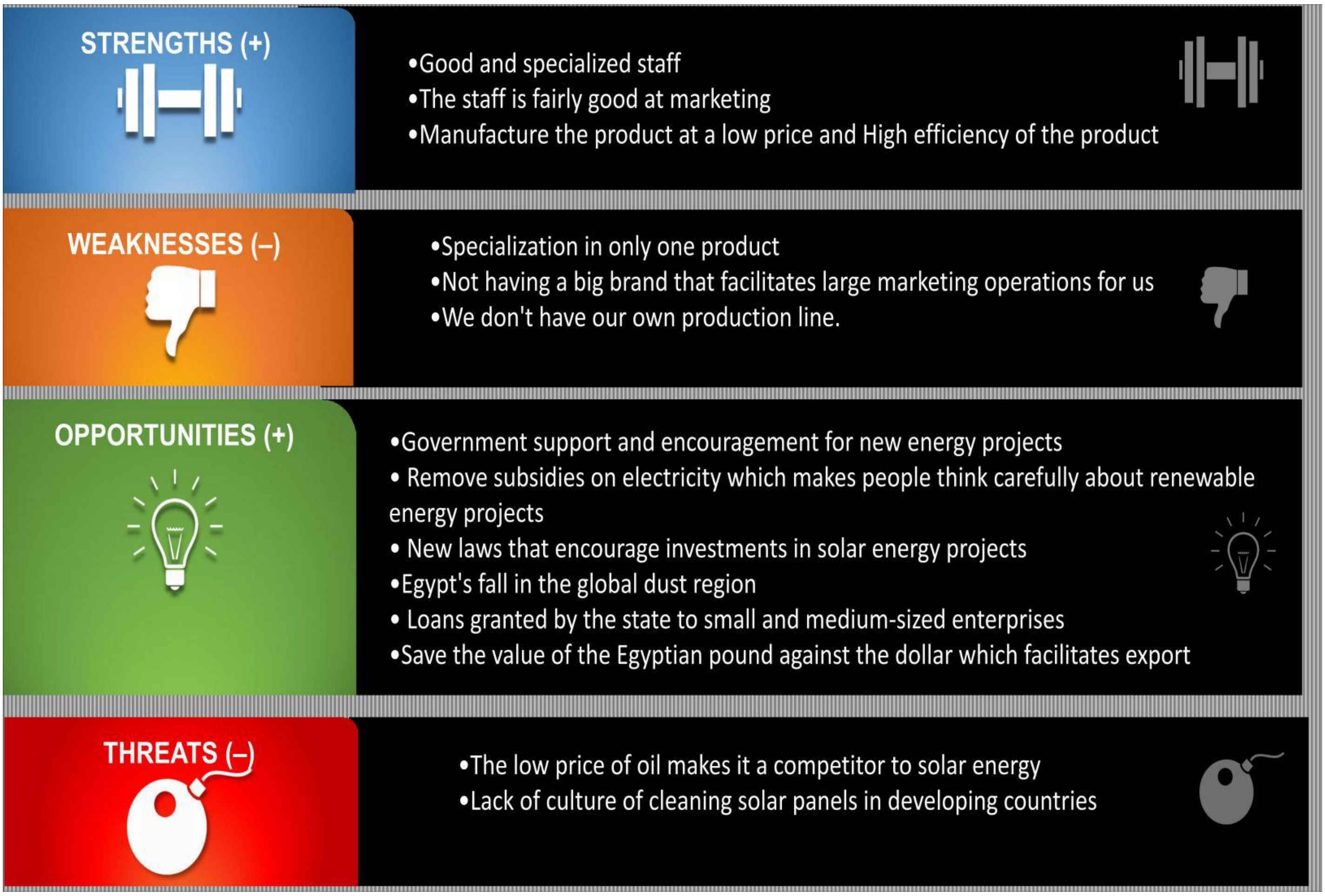
Chapter 3 : Project Goals and Deliverables

3.1 Goals :

The main objective of this project is to improve the performance of PV plant

We need to use solar cleaning system to avoid loses in performance and efficiency which come from many states and circumstances

SWOT Analysis :



STRENGTHS (+)

- Good and specialized staff
- The staff is fairly good at marketing
- Manufacture the product at a low price and High efficiency of the product

WEAKNESSES (–)

- Specialization in only one product
- Not having a big brand that facilitates large marketing operations for us
- We don't have our own production line.

OPPORTUNITIES (+)

- Government support and encouragement for new energy projects
- Remove subsidies on electricity which makes people think carefully about renewable energy projects
- New laws that encourage investments in solar energy projects
- Egypt's fall in the global dust region
- Loans granted by the state to small and medium-sized enterprises
- Save the value of the Egyptian pound against the dollar which facilitates export

THREATS (–)

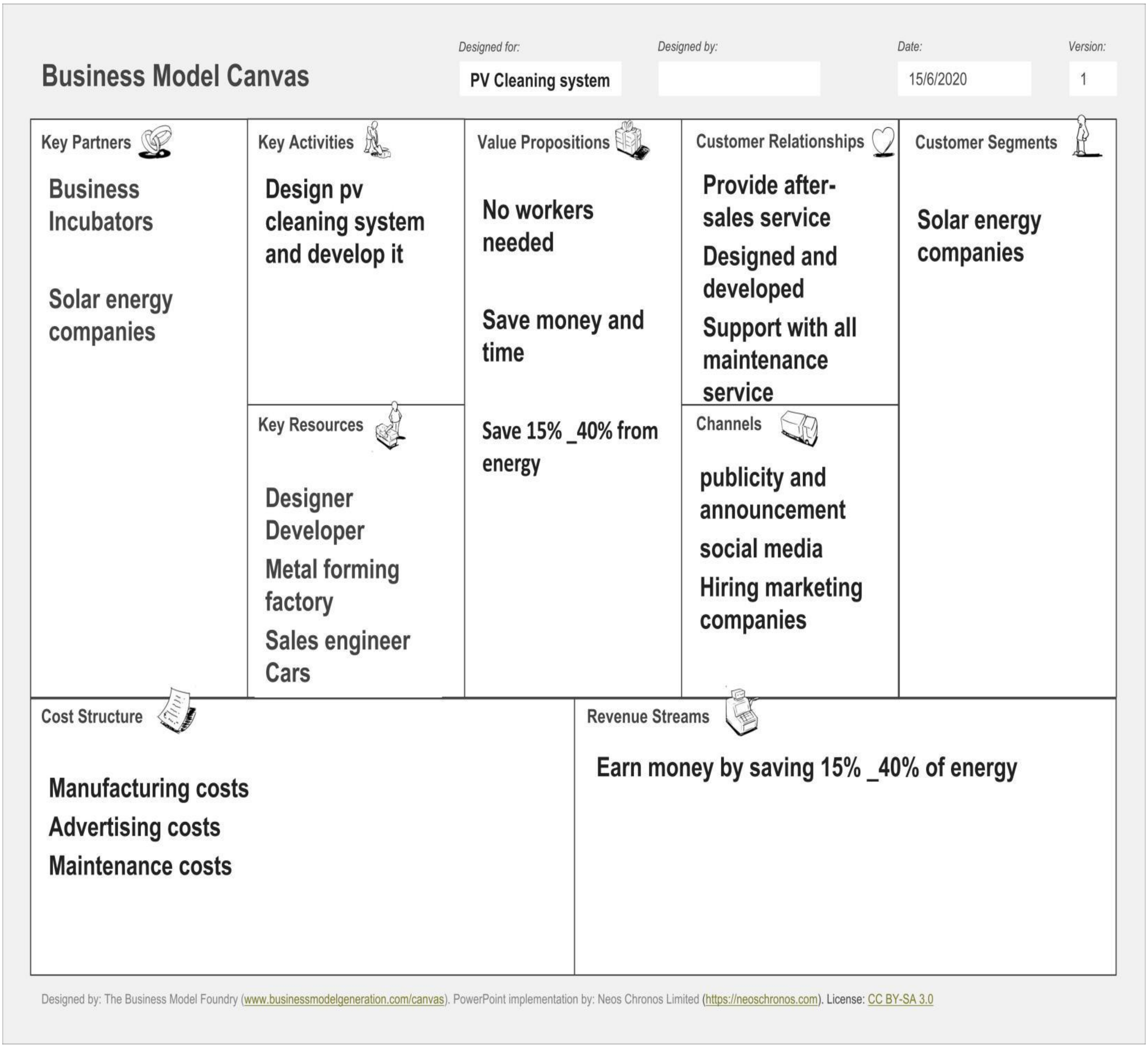
- The low price of oil makes it a competitor to solar energy
- Lack of culture of cleaning solar panels in developing countries

3.2 Project expected outcomes :

Business Plan:

Solar Energy Services Company	
Identity Manufacture of cleaning systems for solar panels to raise their efficiency.	**Problem** Loss of 15% to 40% of solar panel efficiency due to the accumulation of impurities on the panels Huge amount of water is wasted by traditional cleaning methods
Our solution Manufacture of automatic systems used in cleaning solar panels, saving money, labor and water used in cleaning.	**Target market** Solar energy companies Government and private institutions that use solar energy to generate electricity.
The competition There are no companies specialized in this field in Egypt	**Revenue streams** Selling units manufactured to solar energy companies by participating in exhibitions
Marketing activities Participate in renewable energy exhibitions and communicate with companies and institutions working in the field of solar energy. Use the Internet to market the product.	**Expenses** Materials used in manufacturing, such as iron and aluminum The cost of metal forming cutting, bending and welding An inventory space for products The cost of electric motors, control units and sensors
Team and key roles The owner is currently the developers of the project in the future, it is possible to involve someone to increase the cash flow	**Milestones** It is suitable for use at all times, especially after the state put in place an investment law in the field of new energy, set a purchase tariff for energy produced from the sun, and lifted subsidies on electricity

Business Model



Business Model Canvas

Designed for: PV Cleaning system

Designed by:

Date: 15/6/2020

Version: 1

Key Partners

Business Incubators

Solar energy companies

Key Activities

Design pv cleaning system and develop it

Key Resources

Designer
Developer
Metal forming factory
Sales engineer
Cars

Value Propositions

No workers needed

Save money and time

Save 15% _40% from energy

Customer Relationships

Provide after-sales service
Designed and developed
Support with all maintenance service

Channels

publicity and announcement
social media
Hiring marketing companies

Customer Segments

Solar energy companies

Cost Structure

Manufacturing costs
Advertising costs
Maintenance costs

Revenue Streams

Earn money by saving 15% _40% of energy

Designed by: The Business Model Foundry (www.businessmodelgeneration.com/canvas). PowerPoint implementation by: Neos Chronos Limited (https://neoschronos.com). License: CC BY-SA 3.0

Feasibility of project :-

By collecting all information which related to PV cleaning system about project and then analysis it

And execute two studies

1) Strategic analysis

2) Financial analysis

Economic feasibility study:-

is a scientific pattern for knowing the probabilities of the success of an investment idea before the actual implementation

Payback period

time during which the initial cost is recovered from the cash receipts

is defined by the number of years and the payback period is calculated according to

The case of equal cash inflows

Annual net cash inflows

$$\textbf{Payback period} = \frac{\textbf{Total investment required}}{\textbf{Annual net cash inflows}}$$

Annual net cash in flows

Power = 500 Kw

E = p * t = 500 kw * 7 hr * 365/year

$E = 1277500\ {kw.hr}/{year}$

Ratio of losses between 15% to 40% so we use average between it which equal 25% (.25)

Energy losses = 0.25 * 1277500 = 319375 kw.hr

Energy losses in \$ =319375 ${kw}/{hr}$ * 0.788 \$ = 25166.75 \$/year

Total investment required

Quantity * price of system (in \$)= 10*(15000/16) = 10* 937.5 = 9375 \$

$$\textbf{Payback period} = \frac{\textbf{9375 \$}}{\textbf{25166.75 \$/year}} = \textbf{0.37 year} = \textbf{4.47 month} \approx \textbf{5 } \boldsymbol{month}$$

So this project is good investment and investor can payback his capital in short time 5 month only and then has all profit from this system

Chapter 4

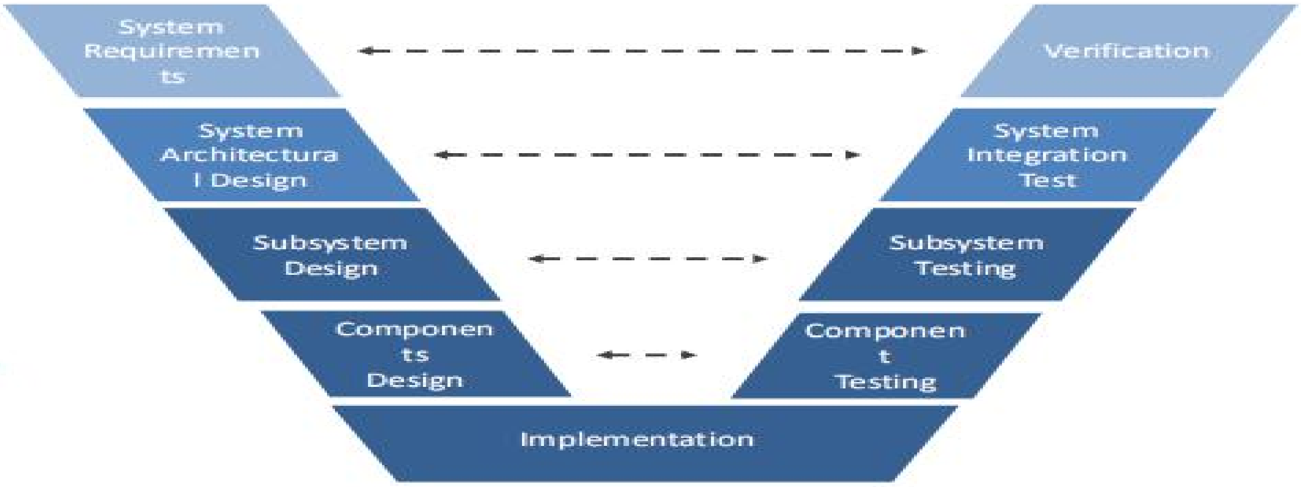
Methodology

Chapter 4: Methodology

4.1 Design Approaches:

V model design Approach :

- V model, testing action, start with the first stage itself. (simultaneous process)
- defects are notice in the initial phases, due to which they can be corrected easily.



Why We use V Model?

It takes a lot of time when we compared with waterfall but it has more accurate and low material usage

How we applied V- Model in our design?

The first step is System Requirement in PV-Cleaning System The requirement is a clean solar cell array and transportation to clean all solar cell in farm our design verification requirement.

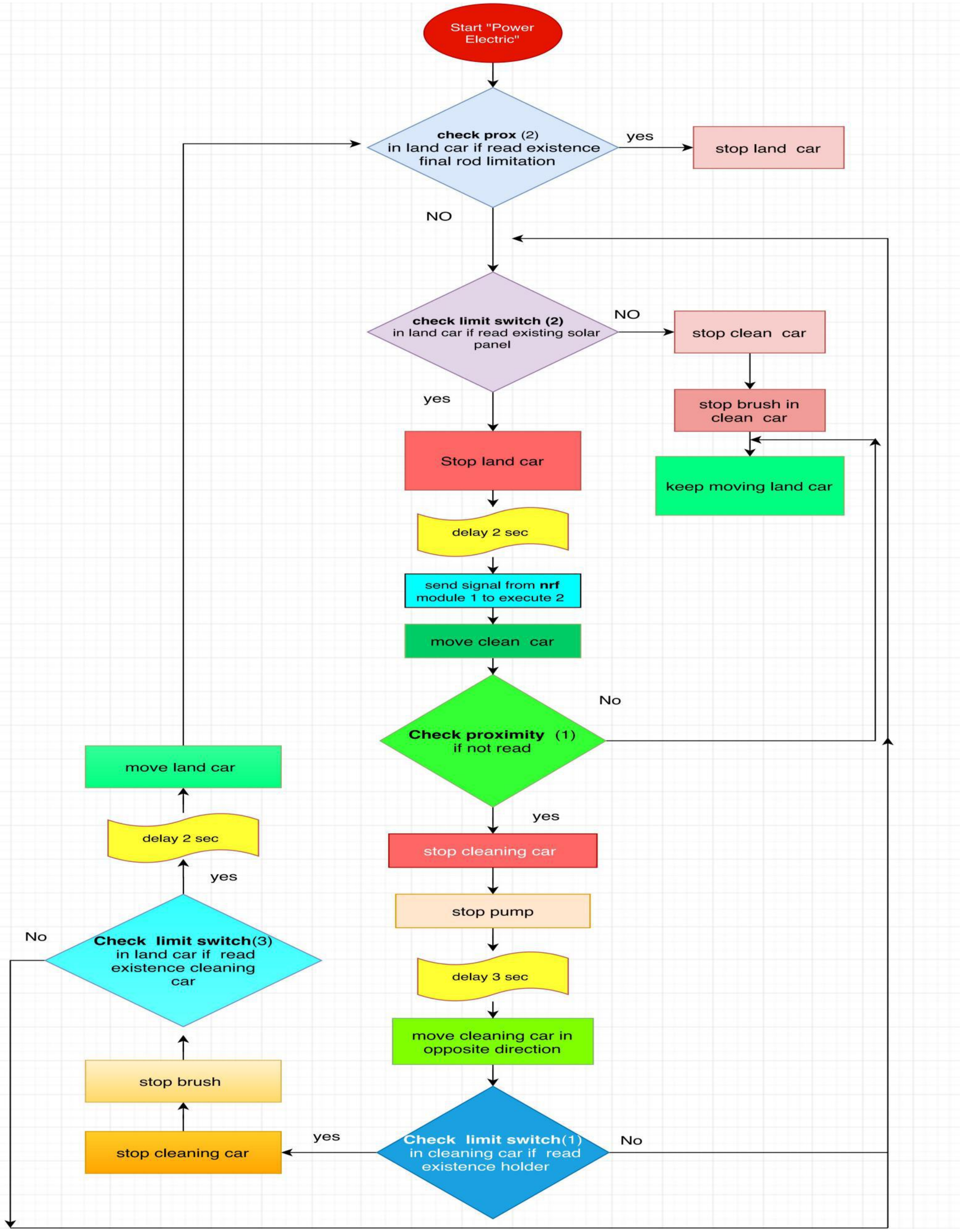
The second step is a system architecture design in PV-Cleaning System in Design we can descript as X-axis and Y-axis and carful no baffles to the system the system Is integration system.

The Third step is subsystem design we divided system to a lot of subsystem because if we have any error an any of subsystem, we can change it very easy and quickly without and effect of the design.

The Forth step is component design it is very important to a good design we consider to choose best material and best price and re-check if this a best material?

After forth steps in V model we can implement The Project

4.2 Flow chart of The System :


Start "Power Electric"
check prox (2) in land car if read existence final rod limitation
yes
stop land car
NO
check limit switch (2) in land car if read existing solar panel
NO
stop clean car
stop brush in clean car
keep moving land car
yes
Stop land car
delay 2 sec
send signal from nrf module 1 to execute 2
move clean car
No
Check proximity (1) if not read
yes
stop cleaning car
stop pump
delay 3 sec
move cleaning car in opposite direction
Check limit switch(1) in cleaning car if read existence holder
No
yes
stop cleaning car
stop brush
Check limit switch(3) in land car if read existence cleaning car
No
yes
delay 2 sec
move land car

4.3 Mechanical Design :-

Frame Design

We choose aluminum material to make our robot for its light weight and strength

Aluminum rectangle with dimensions of 2 m by 0.4 m to cover a whole module at each time with two motors

micro fabric brushes to guarantee that the dust gets swept towards the bottom and not just transported sideways

wheel can fit to the left or right of the gearbox and motor can be run in both forward and reverse directions. [14]

Mechanical working operation:-

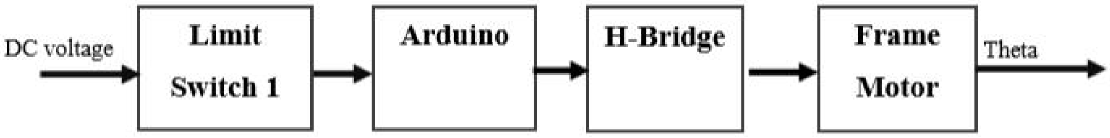
- Specify the all component of project
- Specify all mechanical operation and target of system
- Designing the mechanical system related to standard dimensions which used such as standard dimension of automated cleaning carriage related to standard dimension of solar panel which used

4.4 Electrical design:-

in project, we use certain power as calculated and to achieve that we need to measure voltage and current At All time

So, to do that we try build a dummy load to consume the power generated from the cell and connect a voltage and current sensors to read the data to Arduino

DC motor with right angled drive reduction gearbox and rubber wheel.



4.5 Fluid system Design:-

Centrifugal of Pump operation is :

if it is impeller centrifugal rotates and fluid is absorbed in through the body is suction process through the casing and flows radial outward.

Energy is add to the fluid by the rotating blades , and both pressure and absolute velocity are increased as the fluid lows the vicinity from the eye to the of the blades**.**

if it is non positive displacement propeller centrifugal the fluid is distinguished with high pressure and low volume to have axial pump

[17]

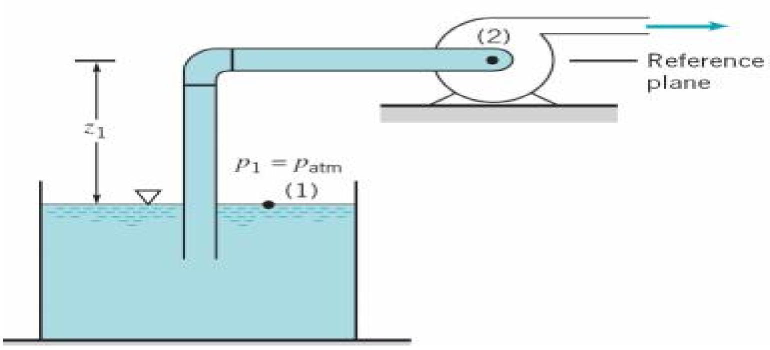


Fig 4-1 : fluid operation

4.6 component which used

Proximity sensor :

Proximity sensors are used in many industrial applications. These sensors are used by feeling the presence of objects or substances and then something is reported. One of the advantages is that she doesn't need physical contact with the material. [15]

Limit switch :

A limit switch is a key that is activated by the movement of the device or the presence of an object or something. The limit switch is used as a safety interlock tool or can be part of the control system. When a object touches the limit switch , the device activates the connection to cut off any electrical connection . Limit switches are used in many applications and environments due to their ease of handling, installation and rigidity. It can determine the presence or absence of an object [15]

DC motor :

we focused on the use of DC motors for moving the cleaning robot and brush for the following reasons. Both the weight and price of dc motor is better than stepper motor. So we use DC motor for drive brush and in moving and stepper motor in forming the certain angle.

Servo motor :

To make the slope of the panel (β) To make the project used in several places, for example, in Banban station β = 15 °

In cairo β = 25 ° - 30 °

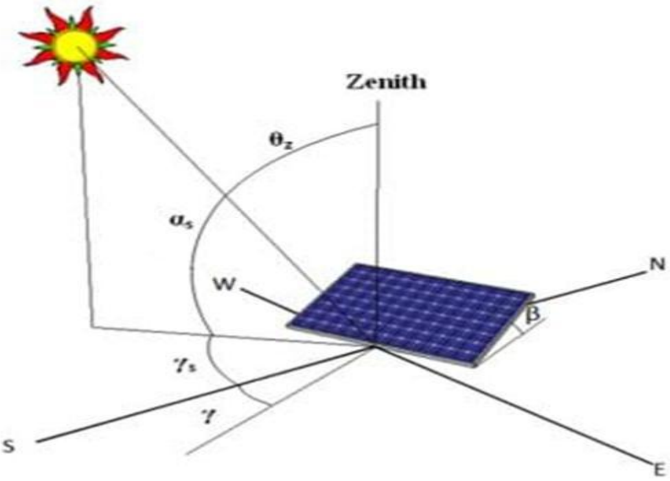


Fig 4-2 : Solar Angles

Relay Module 4 channel :

To control the direction of Dc motor

IN1--IN4: Relay control port

Output:

DC 30V/10A, AC 250V/10A

- used to control DC motor with large current..
- Easy to use control logic
- . • Current monitoring for each channel.

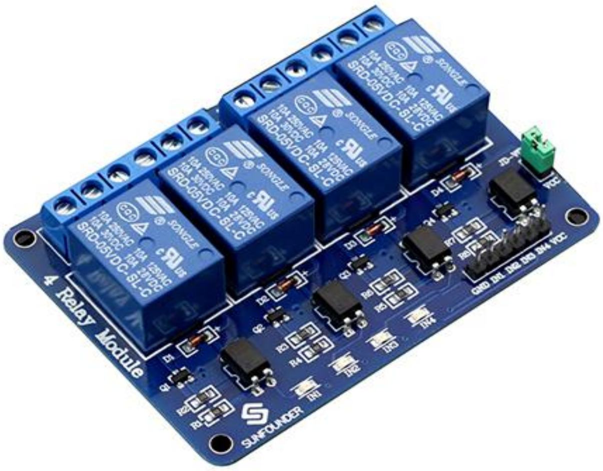


Fig 4-3 : Relay Module 4 channel

[15]

Wireless Module nrf 24L01 :

The wireless NRF24L01P + module with an amplifier and an external antenna operates at an unlicensed frequency of 2.4 GHz and can operate at a distance of up to 1100 meters. Each module can be programmatically installed as a receiver or transmitter, and star networks can also be built. The module has a small size (45.54 x 16.46 mm), controlled by the SPI protocol.

Attention! The modules use a standard pin out, you should not pay attention to secondary designations (on the modules themselves the pin out may be indicated incorrectly).

Specifications:

transmit power more than +20 dtsBm, 50Ω, supports seven-channel reception, transmission speed up to 2 Mbps

operating voltage 2.7 - 3.6V, but the control pins are tolerant to 5V (that is, we power strictly up to 3.6, but we connect the control pins to Arduino pins
without problems)

multi-frequency points: 125 frequency points

supports forwarding of lost packets

operating frequency: 2400 - 2524 MHz

modulation: GMSK

receiver sensitivity: -95 dtsBm

maximum transmission current: 115 mA

maximum reception current: 45 mA

operating temperature range: industry standard -45 ... +85 degrees

PA gain: 20dB

LNA amplification: 10dB

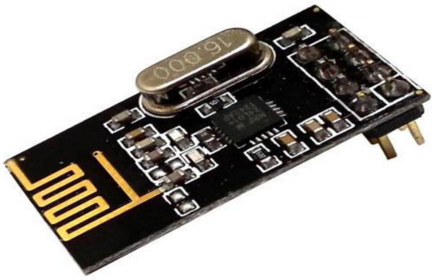


Fig 4-4 Wireless module

The module has a standard pin out that allows you to connect it to Arduino boards that have a connector for NRF24L01P + modules (for example, this, this, this, this, this or this) or simply to the SPI interface of the Arduino board.

4.7 Selection of motor

Newton's second law

Newton's second law (for translational motion). $\text{acceleration} = \dfrac{\text{force}}{\text{mass}}$

(mass) (acceleration) = force

$$ma = \sum F$$

Newton's second law (for rotational motion).

(moment of inertia) (angular acceleration) = torque $J\alpha = \sum T$

Gives the force-acceleration relationship of a rigid translating body or the torque-angular acceleration relationship of a rigid rotating body.

[18]

Density of aluminum (ρ aluminum) = 2800 Kg/m^3

Cross sectional area of the frame (frame) =(30*101)cm^2

Mass total= 9.8 kg

Mass of brushes = 1 Kg

Mass of cover = 2 Kg

Brush total diameter = 15cm

Diameter of nozzle for irrigation =0.2 cm

Diameter of brush =2 cm

Select of Brush motor

M = 1 kg

T_l = TF = ɱ x N xD / 2

T_m =TL+JӪ

J =0.5MD^2

= 0.5x1x(2x10^2) = 2x10^{-4} kg.m^2

Ӫ = ω / ta

= (500/60) /3 = 2.78 rad/s^2

JӪ = 5.56x10^{-4}

T_l = ɱ xN x D/ 2

= 0.3 x 1x9.81 x 15x10^{-2}/2 = 0.2207 N.m

T_m = 0.2207+5.56x10^{-4}

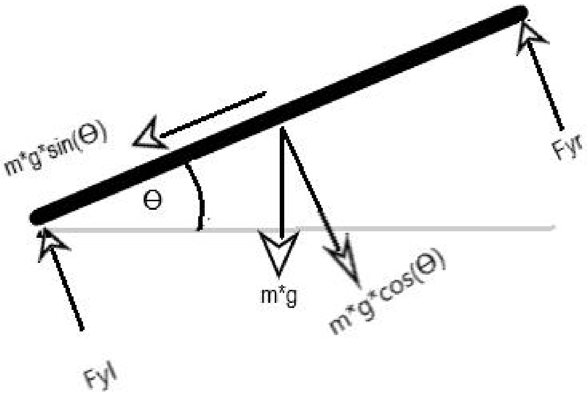
= 0.22128 N.m

T_t = k_s x Tm

= 1.5 x 0.22128 = 0.332 N .m

[18]

Selection of two motors



$D = 8$ Cm

$d = 42$ mm

$M = 15$ kg

$\Sigma F_y = 0$

$F_{yl} + F_{yr} = Mg\cos(\Theta)$

$= 15 \times 9.81 \times \cos(35) = 120.5$ N

$\Sigma M = 0$

$120.5 \times 0.5 - F_{yr} \times 1 = 0$

$N = F_{yr} = 60.25$ N

$T_M = T_L + J\ddot{\Theta}$

$T_L = \mu \times F \times \sin(\Theta) \times d/2 + \mu \times N \times D/2$

$= 0.3 \times 15 \times 9.81 \times \sin(35) \times 42 \times 10^{-3}/2 + 0.6 \times 60.25 \times 8 \times 10^{-2}/2$

$= 0.532 + 1.446 = 1.978$ N.m

$J\ddot{\Theta} = 0.5Md^2 \times \omega/t$

$= 0.5 \times 15 \times (8 \times 10^{-2})^2 \times (83/60)/3$

$= 0.022$

$TM = 1.978 + 0.022$

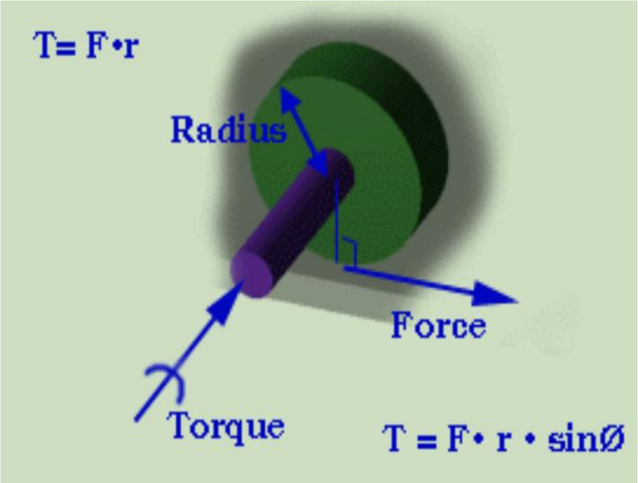
$= 2$ N.m

$T_t = ks \times Tm$

$= 1.5 \times 2 = 3$ N.m

[18]

Selection of two motors for land carriage



[18]

m = 30 Kg

D = 8 Cm

$\mu = 0.3$

$g = 9.8\ m/s^2$

friction force (f_r) = μ x m x g x sin(Θ)

= 0.3x 30 x 9.81 x sin(90)

= 88.29 N

For one wheel f_r = 88.29/2 = 44.15 N

Torque for one wheel (Tm) = f_r x D/2

= 44.15 x 0.08 /2

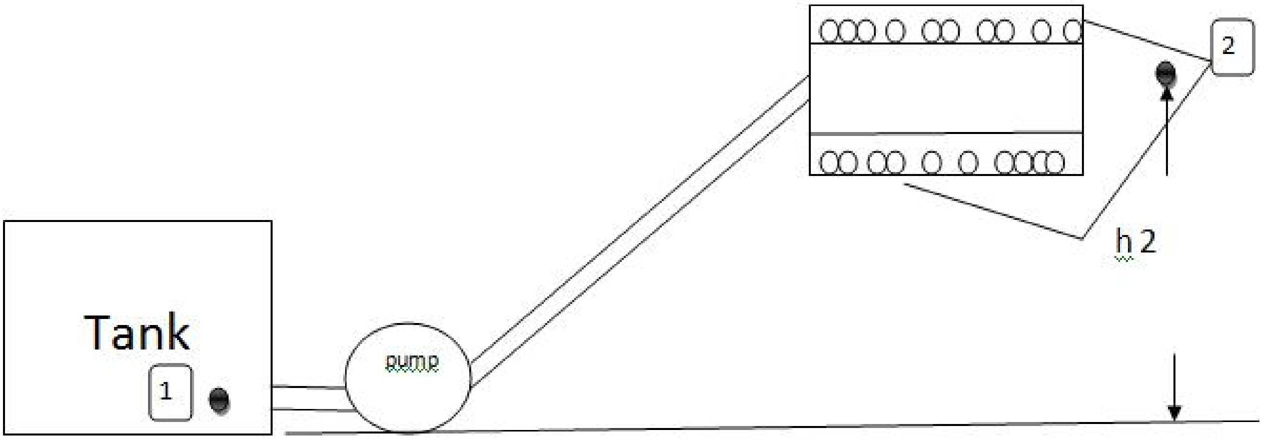
= 1.766 N.m

T = ks x Tm

= 1.5 x 1.766

= 2.65 N.m

4.8 Selection of Pump



h_1=0m ,

V_1=0m/s

,V_2=3m/s

P1=P2= P_{atm}

h_2 =1m

Do = 40mm ,

D_I=80mm

no. of the slots=20 slots

diameter of slots = 1mm

total area of slots= π /4 x 0.001^2 x 20=1.57x10^{-5} m^2

we need velocity at the outlet V4 =3m/s

flow rate of the water at the outlet=VA=1.57x10^-5 x3=4.7 x10^-5 m3 /s=0.0471L/s

we need velocity at the outlet V4 =3m/s

we should be to select centrifugal pump (SC315C75L71) :

--Specification from Data sheet :

Di=3 in , Do=1.5 in ,

Q_{TH} (max)= $30m^3$ / h=$8.333x10^{-3}$ m^3 /s ,

(efficiency) ų =60%,

Q_A = $20m^3$ / h = $5.555x10^{-3}$ m^3/s ,

max head =80m

--The pressure Produced by the pump (Pp) :

--- from Bernoulli is equation :

(P1+ 0.5 ʄ $V1^2$ + ʄ gh1 +Pp = (P2+0.5 ʄ $V2^2$ +ʄ gh2+ ΣH(losses)

ΣH (losses) = f LV^2 / 2gD ,

RE (Reynolds no.) = ʄ VD/ ɥ

ɥ (Viscosity of water)= $1.161x10^{-3}$ m^2/s , V= avg. velocity of fluid

D : diameter of pipe ,

RE=1000 x 3 x 0.04 / $1.161x10^{-3}$ = 103359 is turbulent flow . ,

f = (0.25) / ($\log_{10}$((ϵ/3.7xD) + (5.74/$RE^{0.9}$)) $)^2$

ϵ(roughness) (mm)=1(used hose) ,D (dia. Of pipe)(mm), L (length of pipe) (m), f=0.0536 ,

ΣH(losses) = 0.536*(501/1*10-2)*(32/2*9.8)= 969m

(P1+ 0.5 ʄ $V1^2$ +ʄ gh_1+Pp) = (P_2+0.5 ʄ V_2^2 +ʄ gh_2+ʄ gΣH(losses)

=(0+0+0+Pp)=(0+ 0.5x1000x32 + 1000x9.81x1 +1000x9.81x969=9.51 Mpa

Then from the equation

Pp.=32360 pa (pressure produced) .

The power required =Pp x Q / efficiency of the pump=

=9.51x106 x 4.7x10-5 /0.6 =745 watt [16]

4.9 Electrical Calculations:

$$\underbrace{Ei}_{\substack{\text{electric}\\ \text{power}}} = \underbrace{T\omega}_{\substack{\text{mechanical}\\ \text{power}}}$$

[15]

$P = T \times rpm \times 2\pi / 60$

$V \times I = T \times 2\pi\ n / 60$

Clean Robot motors

For two motor

V = 12 v n= 83 RPM T= 3 N.m

$12 \times I = 3 \times 2\pi\ 83 / 60$

I = 2.2 A

For Brush motor

V = 12 v n = 500 RPM T= 0.332

$12 \times I = 0.332 \times 2\pi \times 500 / 60$

I = 1.45 A

Land Robot motors

For two motor

V = 12 v n =100 RPM T = 2.65 N.m

$12 \times I = 2.65 \times 2\pi\ 100 / 60$

I = 2.3 A

For servo motor

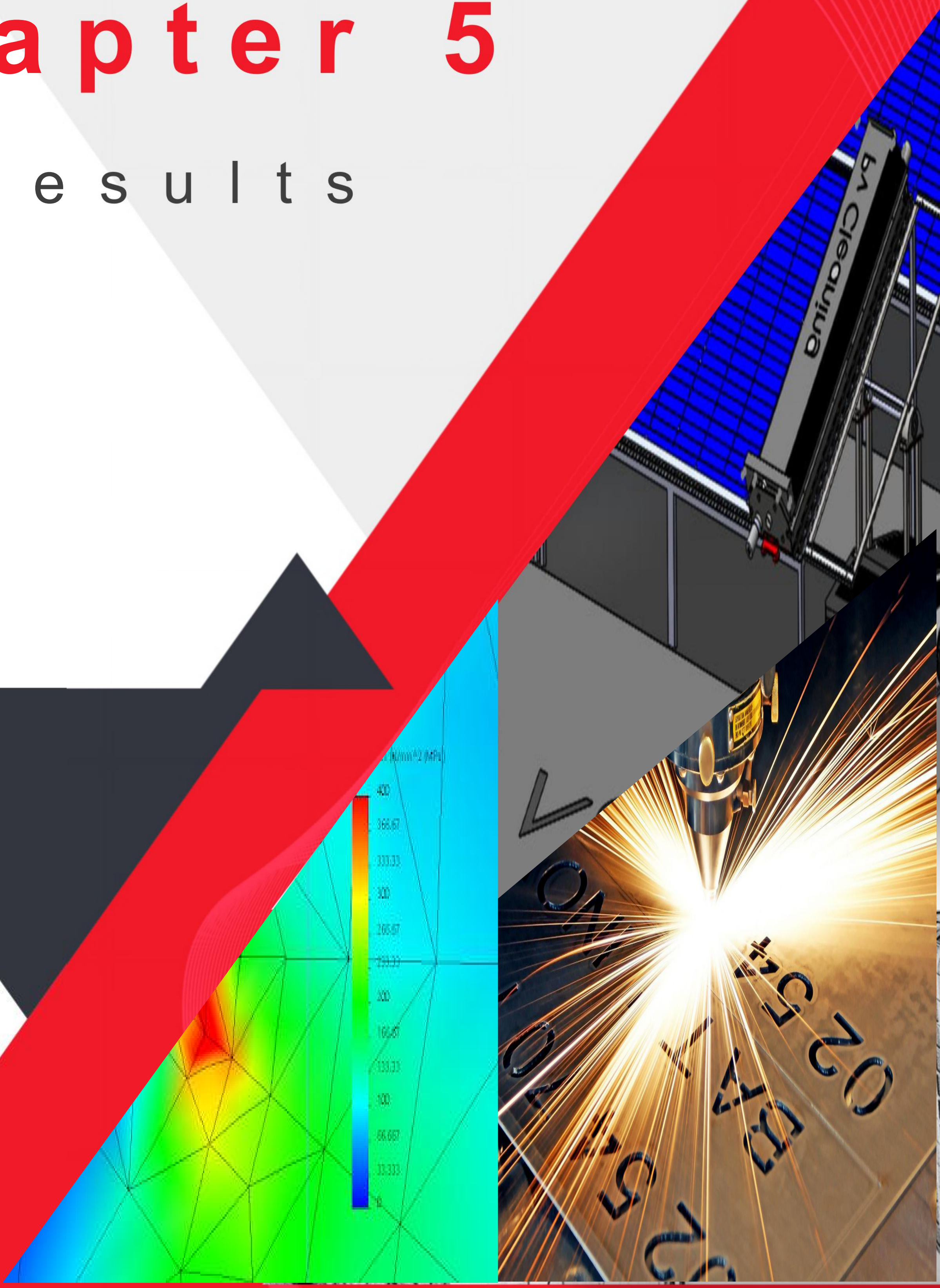
V = 7.4 v ω = 8.055 rad/s T = 3.3 N.m

$7.4 \times I = 3.3 \times 8.055$

I = 3.6 A

Chapter 5

Results



Chapter 5: Results

5.1 Design :

5.1.1 Mechanical Parts Design

Design part is very important to success The project , we are work hard to design The Pv Cleaning System we Consider easy design, low cost material and high quality . design part can take a lot of time because some of edit in electrical design Team and calculation parts in design and, solve problem like how Table move With Angle and High Of solar cell.

Isometric view:

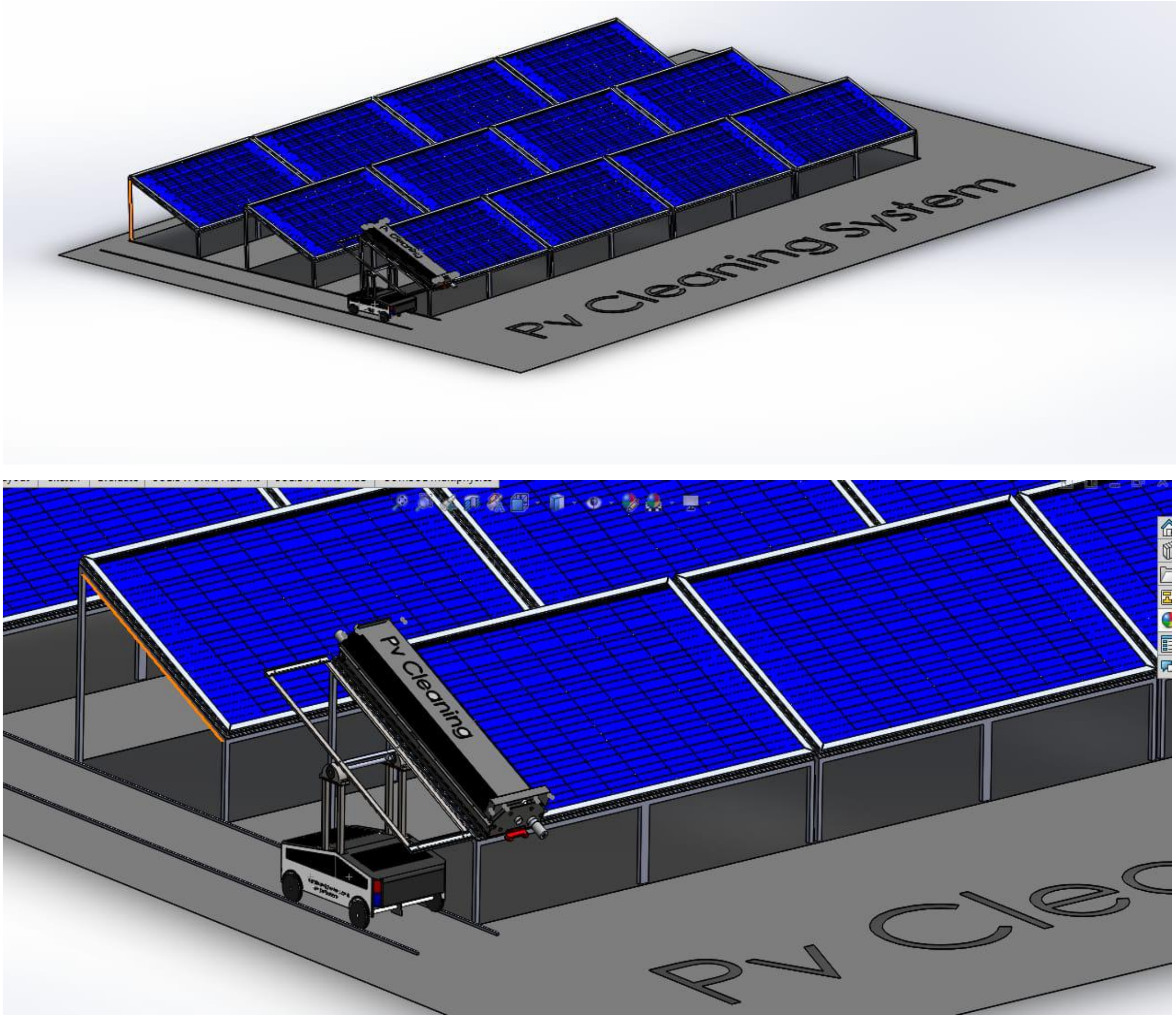


Fig 5-1: isometric view for PV Cleaning System

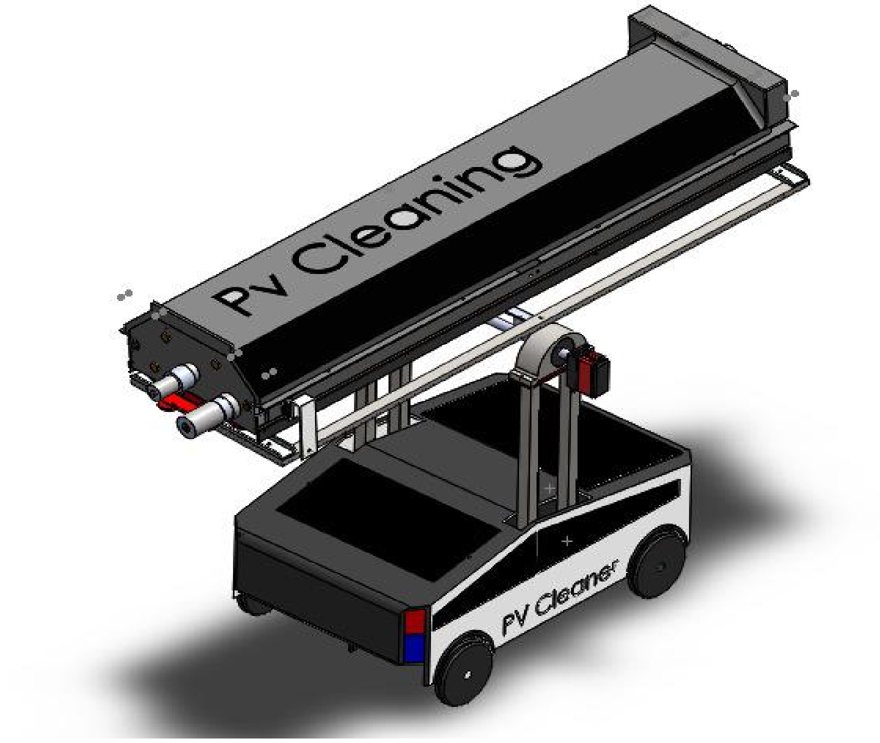


Fig 5-2 : isometric view for project

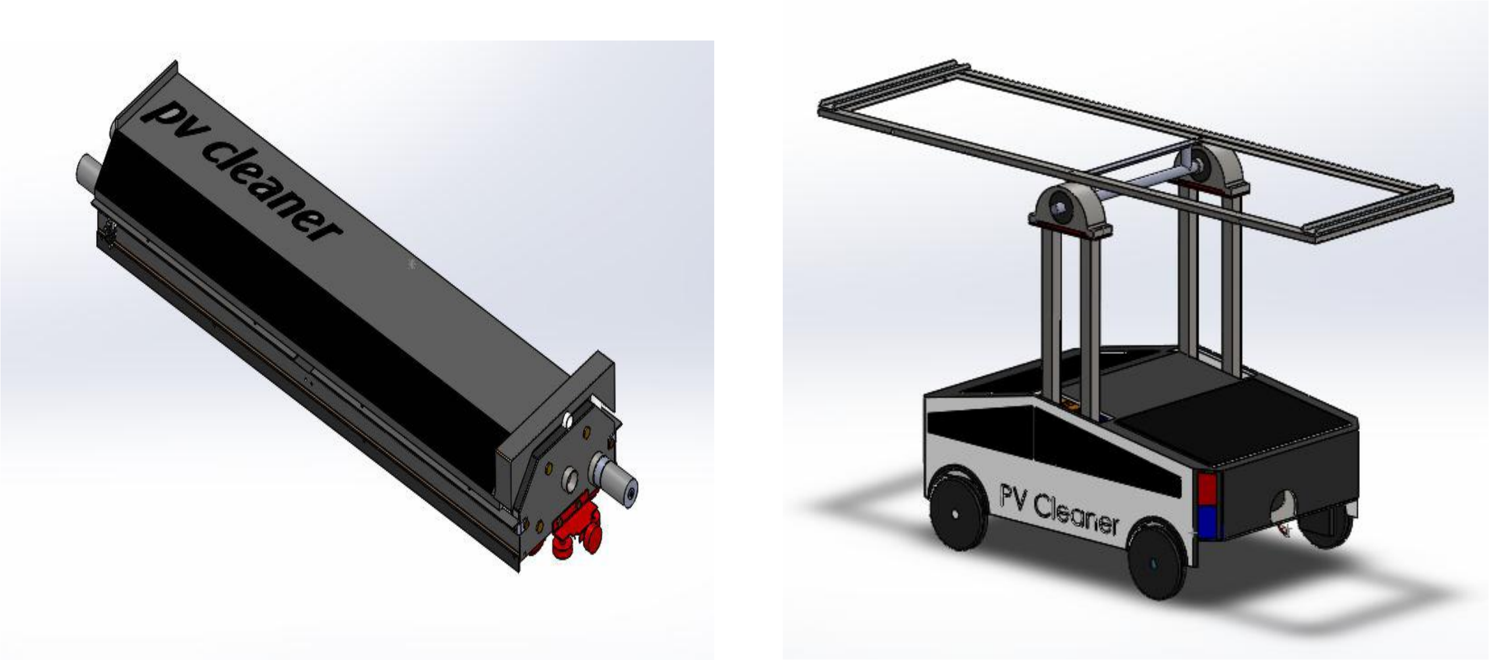


Fig 5-3: isometric view for cleaning and land Robot in solid works

Cleaning Robot system :-

The main purpose of PV Cleaning is Quickly Clean The Solar cell Without negative effect With a suitable size and ideal weight of no more than 12 Kg, it is easy to carry and store We will explain in detail about the parts.

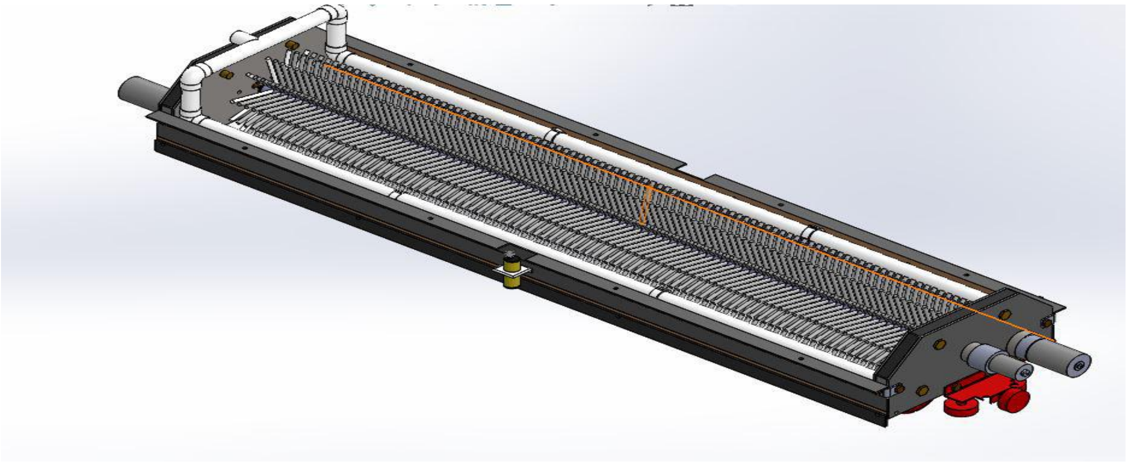


Fig 5-4 : Assembly for cleaning carriage in solid works

Brush design :

it is important part for Pv-Cleaning we consider choose best martial without Negative impact on the panels the brush with nylon filling are suitable for various applications, from aggressive cleaning to dusting, both in dry and in wet environments , excellent fatigue life ,good abrasion resistance, low and moderate water absorption (from 3% to 9%),leading only to a temporary decrease in stiffness, excellent bending recovery rate, resistance to most common solvents and suitability for use in weak acids , and it low cost .

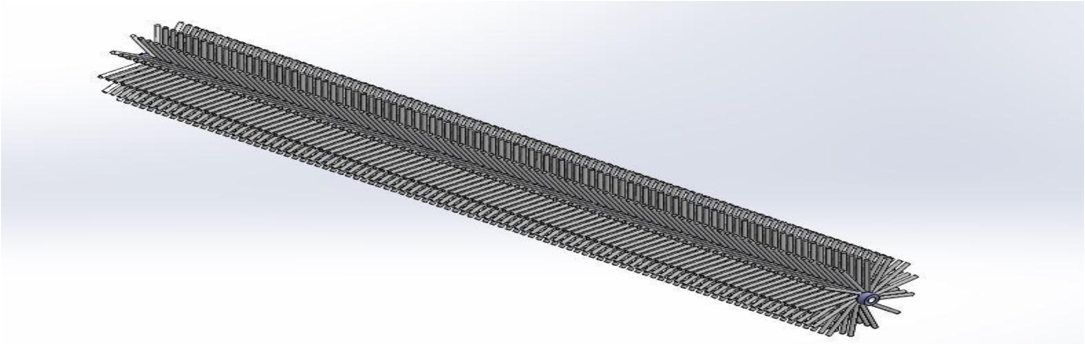


Fig 5-5 : Assembly for brush in solidworks

Right side:

Contains motors and bearings and is designed from aluminum to ensure weld and for the efficiency of the motor , side wheel and the aluminum Lighter than the metal

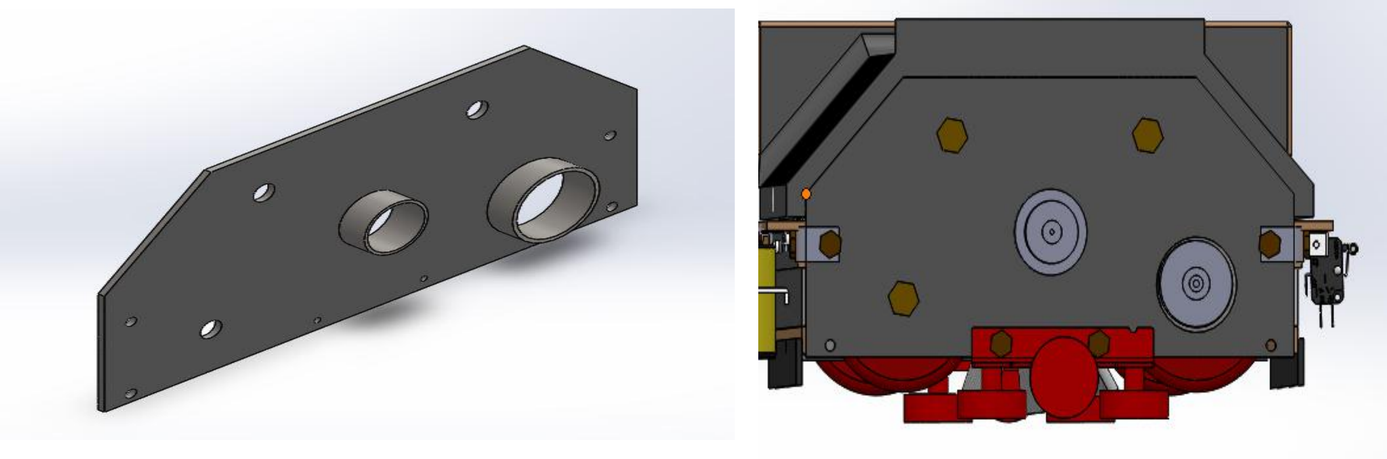


Fig 5-6: Assembly for Right side

Front side :

Made of aluminum to be lightweight on solar panels , it's assist wiper , sensor and pipe .

Wiper: Used to get rid of excess water without affecting the plate.

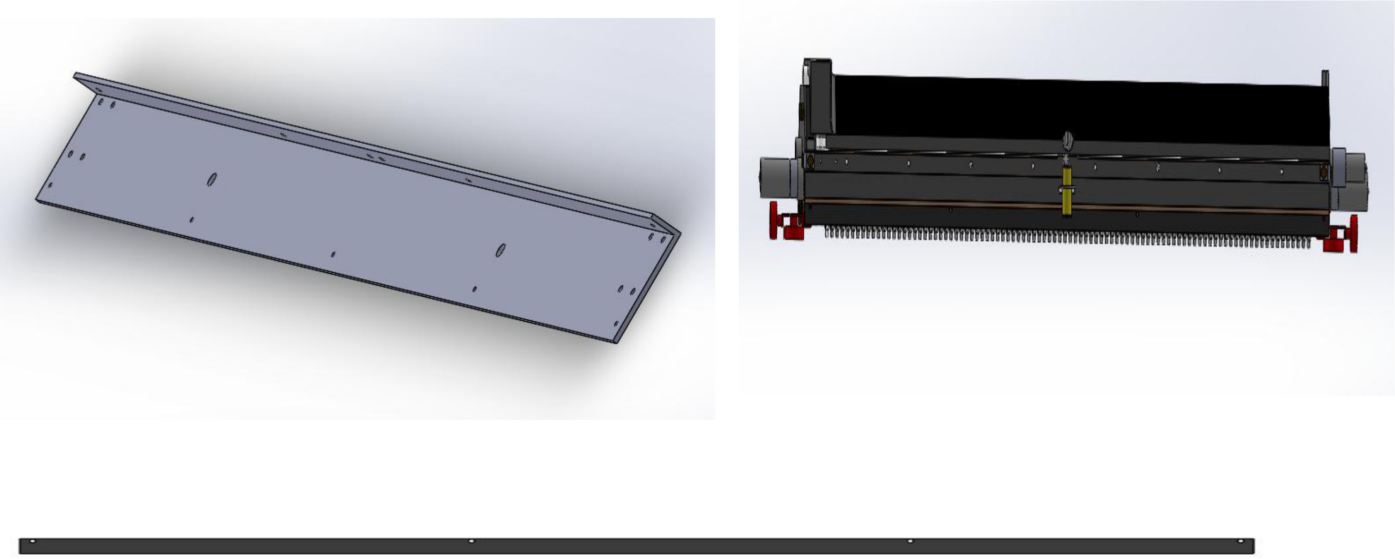


Fig 5-7: Assembly for Front side

Wheel :

Designed for movement on the outskirts of the solar panels it made from Artelon to benefit from its temperature resistance which provide high performance in moving and by its low Density ,low weight And by Artelon properties [low friction] make wheels move on panel boundary smoothly And by time no fear of burning or flaming because this material High thermal stability & flame resistance .

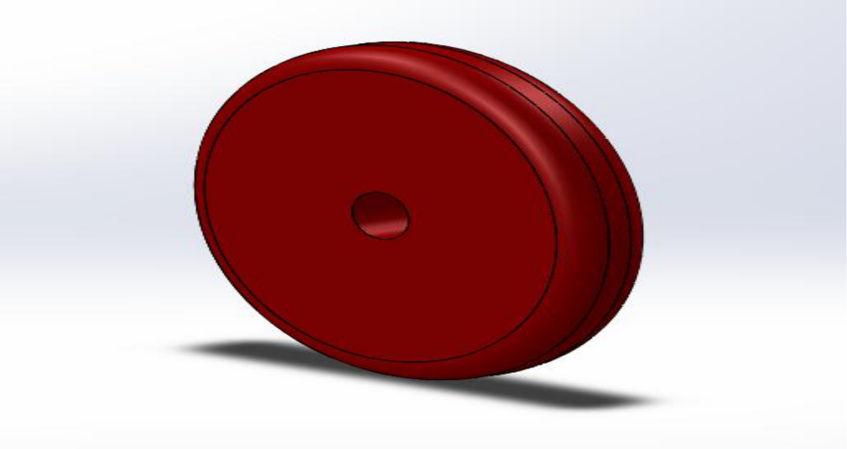


Fig 5-8 : Assembly for Wheel

Assistant wheel :

It is used to keep the pv-cleaner car because it is stable and made from plastic because it is easy to shape, fast to implement and low cost .

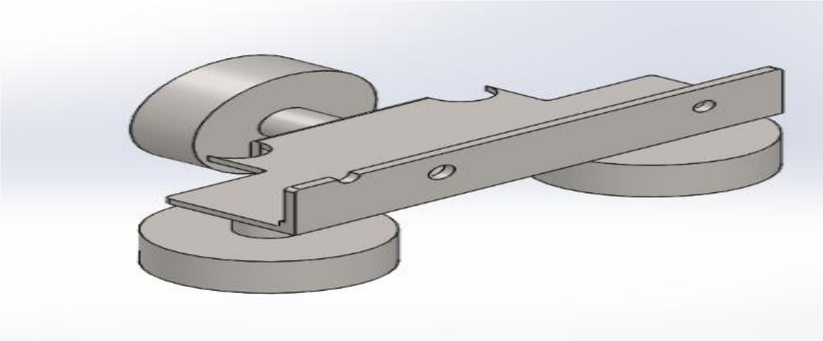


Fig 5-9 : Assembly for Assistant wheel

PVC :

Use PVC pipe in water Transition

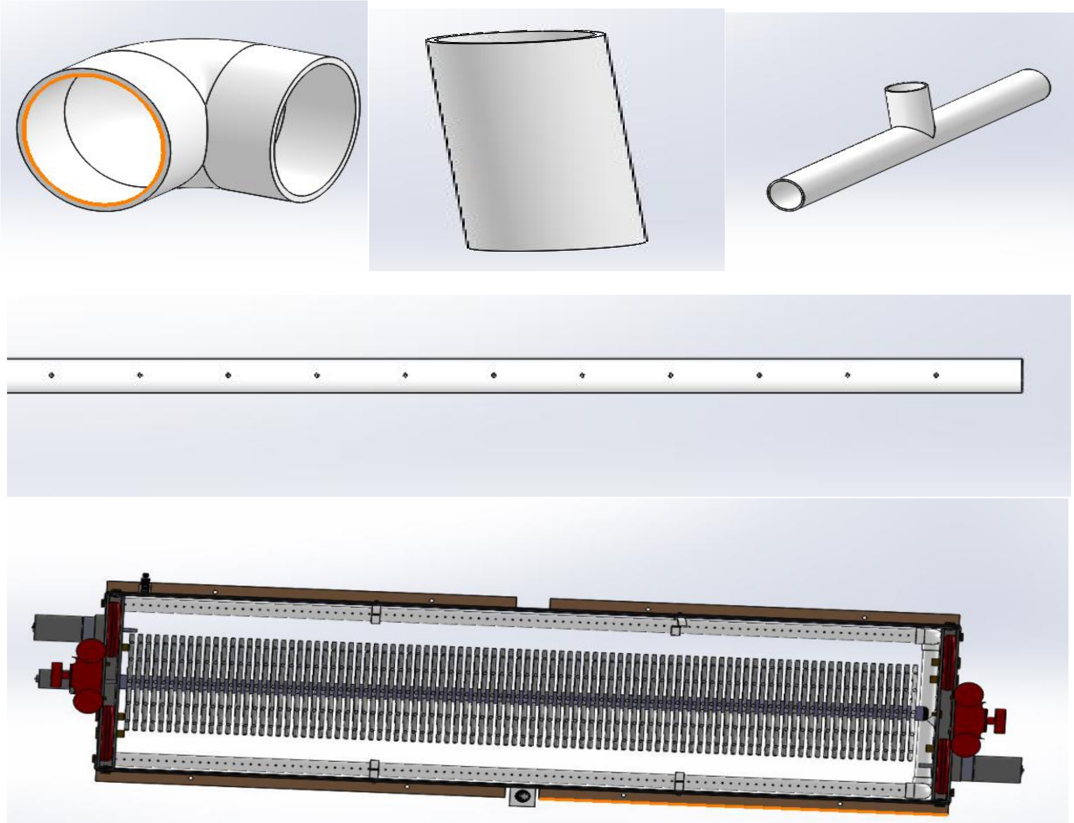


Fig 5-10 : PVC pipelines

Cover :

Streamlined design to avoid air resistance and made of aluminum to be lightweight .

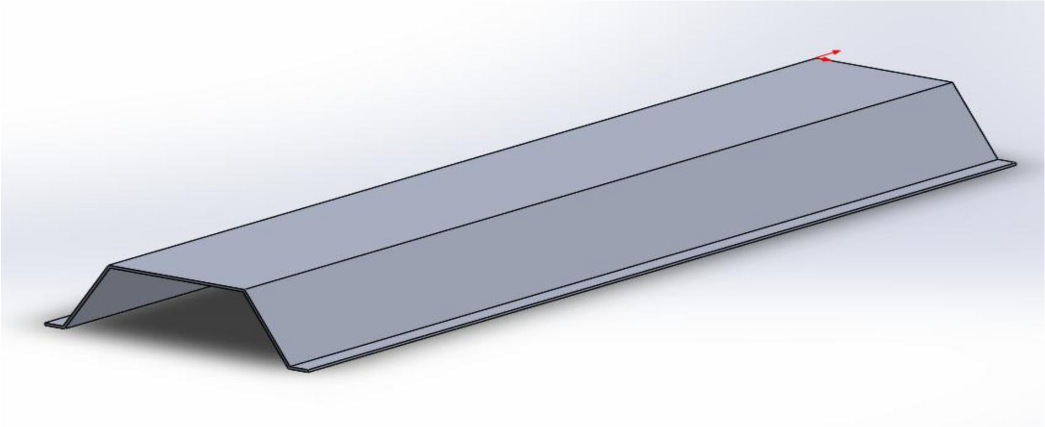


Fig 5-11 : Assembly for Cover

Land carriage system :-

In Land Car we Consider The gravity Center when Pv Cleaning car move out to save the body Stable We will explain in detail about the parts .

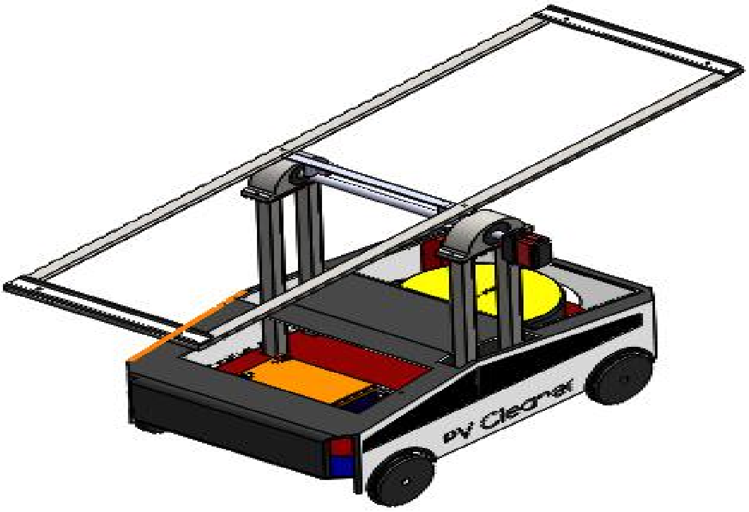


Fig 5-12: Assembly for land carriage

Bearing Holder Stand :

it is placed bearing holder and it It helps raise the table to the required height based on the height of the solar cells it made from steel because it is high tensile strength 410 Mpa ,high stiffness, and good weldability.

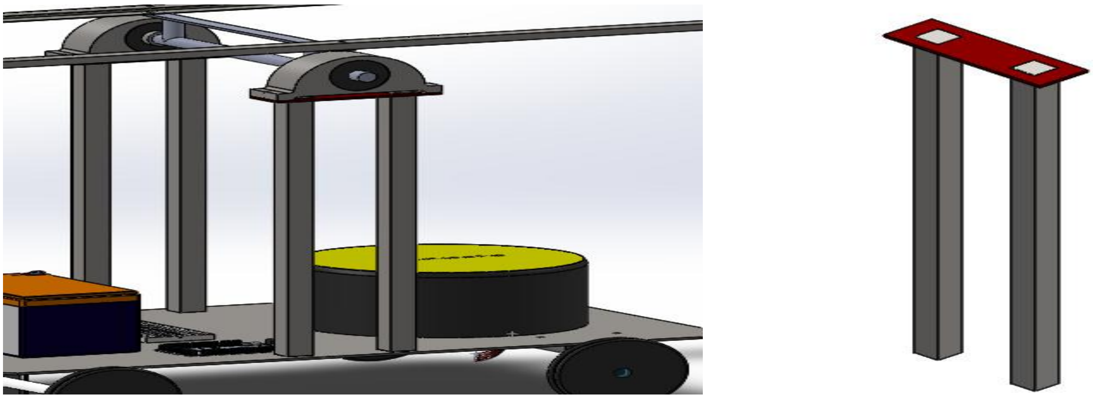


Fig 5-13 : Assembly for Bearing Holder Stand

PV Cleaner Table :

it use to carry The Pv Cleaning Car it made from metal AISI 1020 because it is high tensile strength 410-,high stiffness, and good weld ability.

Wheel path : we use Two wheel path Track movement of the wheel to ensure that it does not slip , it is made from aluminum because it is low density, is non-toxic, has excellent corrosion resistance and can be easy to cast, machined and formed. It is also non-magnetic and non-sparking. It is the second most malleable metal and the sixth most ductile and we test stress analysis give excellent result

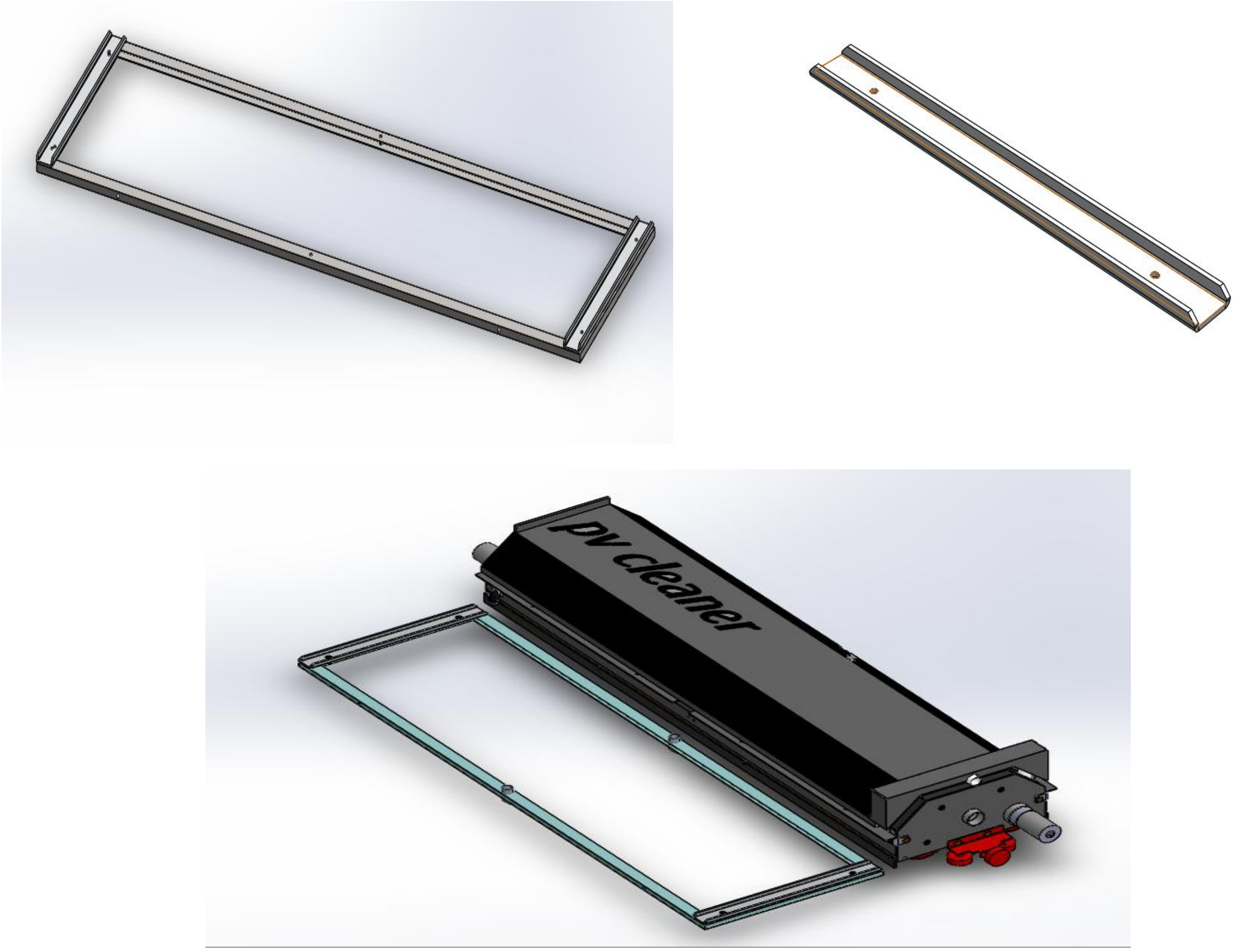


Fig 5-14 : Assembly for Table

Base :

it made From Steel AISI 1020 it is high tensile strength 410 Mpa ,high stiffness, and good weldability , connection with Motor holder and Bearing Holder Stand And it is placed on it the tank and electricity connections.

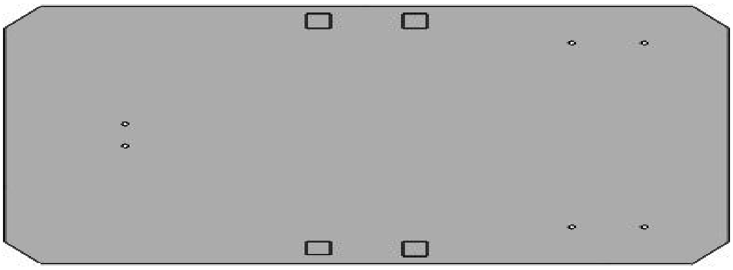


Fig 5-15 : Assembly of Base

Shaft :

it Use to change Angle of The Table it Made from Steel Aisi 304 carbon Additives , which is more expensive than other types, but becomes stiffer , stronger ,Resistant to wear and less ductility , it high tensile strength 505 Mpa

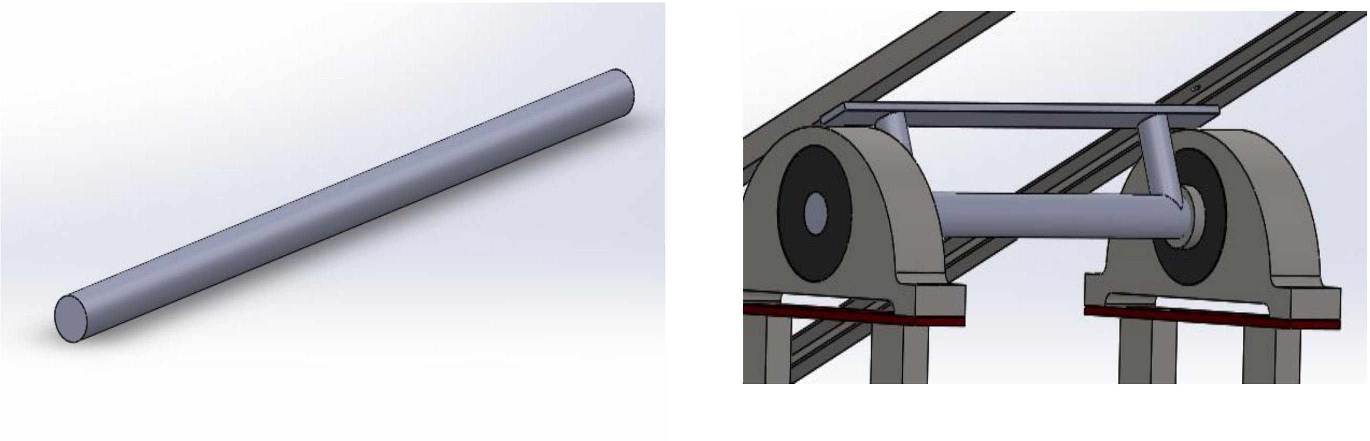
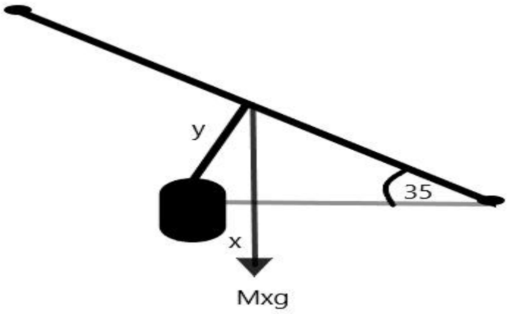


Fig 5-16 : Assembly of shaft

Shaft Design :



$M=13$ kg

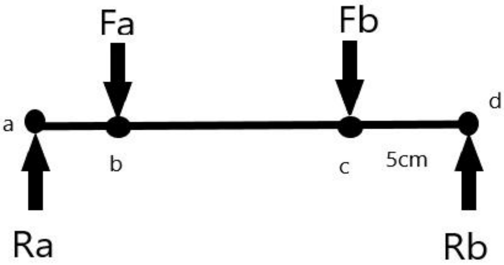
$y=30$ mm

$X= 30 \times \sin(35) = 17.21$ mm

$T = M \times g \times X$

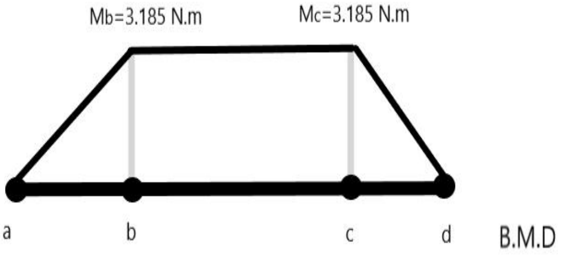
$= 13 \times 9.81 \times 17.21 \times 10^{-3} = 2.2$ N.m

$T = ks \times T = 1.5 \times 2.2 = 3.3$ N.m



$Fa = Fb = 13 \times 9.81 /2 = 63.77$ N

$Mb = 63.77 \times 5 \times 10^{-2} = 3.185$ N.m



ASME code for shaft design

$$d=\left[\frac{16}{\pi\tau_p}\sqrt{(C_m M)^2+(C_t T)^2}\right]^{\frac{1}{3}}$$

$$\tau_p = smaller \begin{cases} 0.3 S_y \\ 0.18 S_u \end{cases}$$

$C_m=2$ $C_t = 1.5$

Fot steel 1020 $S_y = 210$ MPa $S_u = 380$ MPa

$$d= \left(16/\pi x 63x10^6\sqrt{(2x3.185)^2+(1.5*3.3)^2}\right)^{(\frac{1}{3})}$$

d = 8.6 mm for ks =1.8

d = 8.6 *1.8

d = 15 mm

[14]

Bearing Design :

Why use ball bearing ?

it is rolling bearing element which use balls to lead to maintain the space between the moving pieces of bearings (outer and inner part of the bearings).

The ball bearing Advantages is reducing rotary friction and supporting axial loads and radial loads. Ball bearing is simple design, continually at operation and easy in maintaining .

It is suitable in single and Multiple row designs and in open and closed sealed forms. Because of its low frictional torque so it is Available for high speeds.

Fig 5-17: Ball Bearing

Bearing Selection for cleaning robot

Desired working hours HD = 5000 h

Desired speed n_D = 100 rpm

Desired reliability $R_D = 0.99$ Overload factor $a_f = 1.2$

V=1 for inner ring rotates a = 3 for ball bearings

$F_a = 1 \times 9.81 \times \sin(35) = 5.6$ N

$F_r = 1 \times 9.81 \times \cos(35) = 8$ N

Equivalent radial load factors for ball bearings $X_2 = 0.56$ $Y_2 = 2.3$

$F_e = X_2 V F_r + Y_2 F_a = 0.56 \times 1 \times 8 + 2.3 \times 5.6 = 17.36$ N

$X_D = 60 \times H_D \times n_D / 10^6 = 60 \times 5000 \times 100 / 10^6 = 30$

Weibull parameters $x_o = 0.02$, $\theta = 4.459$ and $b = 1.483$

$C_{10} = a_f \times F_e \times [\ X_D / x_o + (\theta - x_o)(1-R_D)^{1/b}\ ]^{1/a}$

$=1.2 \times 17.36 \times [\ 30 / 0.02 + (4.459 - 0.02)(1-0.99)^{1/1.483}\ ]^{1/3} = 107.4$ N

From Table 2 Dimensions and load ratings for single-row deep groove and angular contact ball bearings

$C_{10} = 4.94$ KN $C_o = 2.12$ KN

Bore = 10 mm
OD = 30 mm

Width = 9 mm

[14]

Bearing Selection for Land carriage

HD = 5000 h

Desired speed nD = 100 rpm

Desired reliability RD = 0.99 Overload factor af = 1.2

V=1 for inner ring rotates a = 3 for ball bearings

Fr =13x 9.81 = 127.53 N

XD = 60 x HD x nD / 106

= 60 x 5000 x 100 / 106 = 30

Weibull parameters xo = 0.02, θ = 4.459 and b = 1.483

C10 = af x Fe x [XD / xo + (θ - xo)(1-RD)1/b] 1/a

=1.2 x 127.53 x [30 / 0.02 +(4.459 – 0.02)(1-0.99)1/1.483] 1/3

= 789 N

From Table 2 Dimensions and load ratings for single-row deep groove and angular contact ball bearings

C10 = 4.94 KN Co = 2.12 KN

Bore = 10 mm OD = 30 mm

Width = 9 mm [14]

5.1.2 Circuit Schematic

Cleaning Robot:

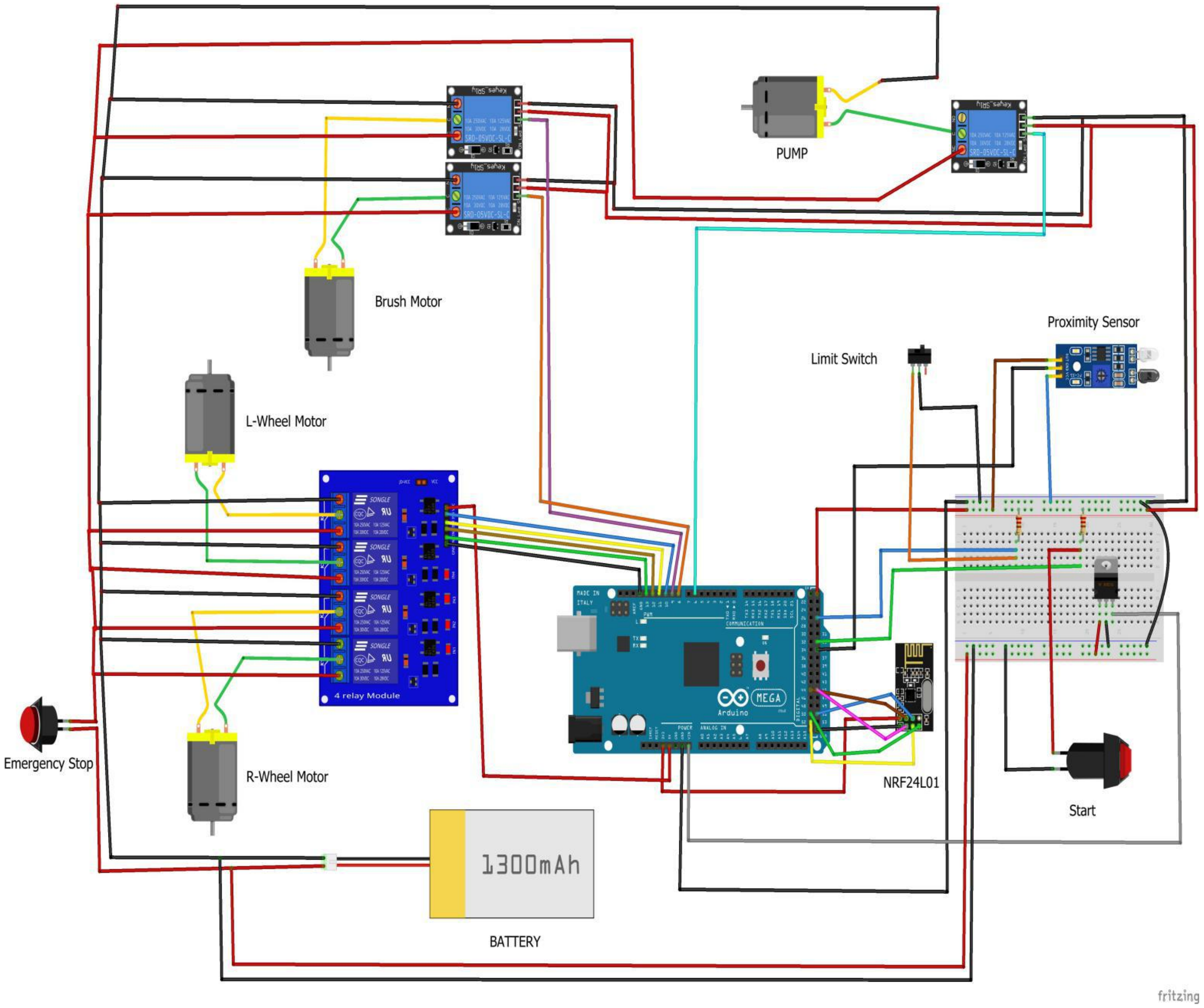


Fig 5-18 : Circuit Schematic of cleaning Robot

Land Carriage:

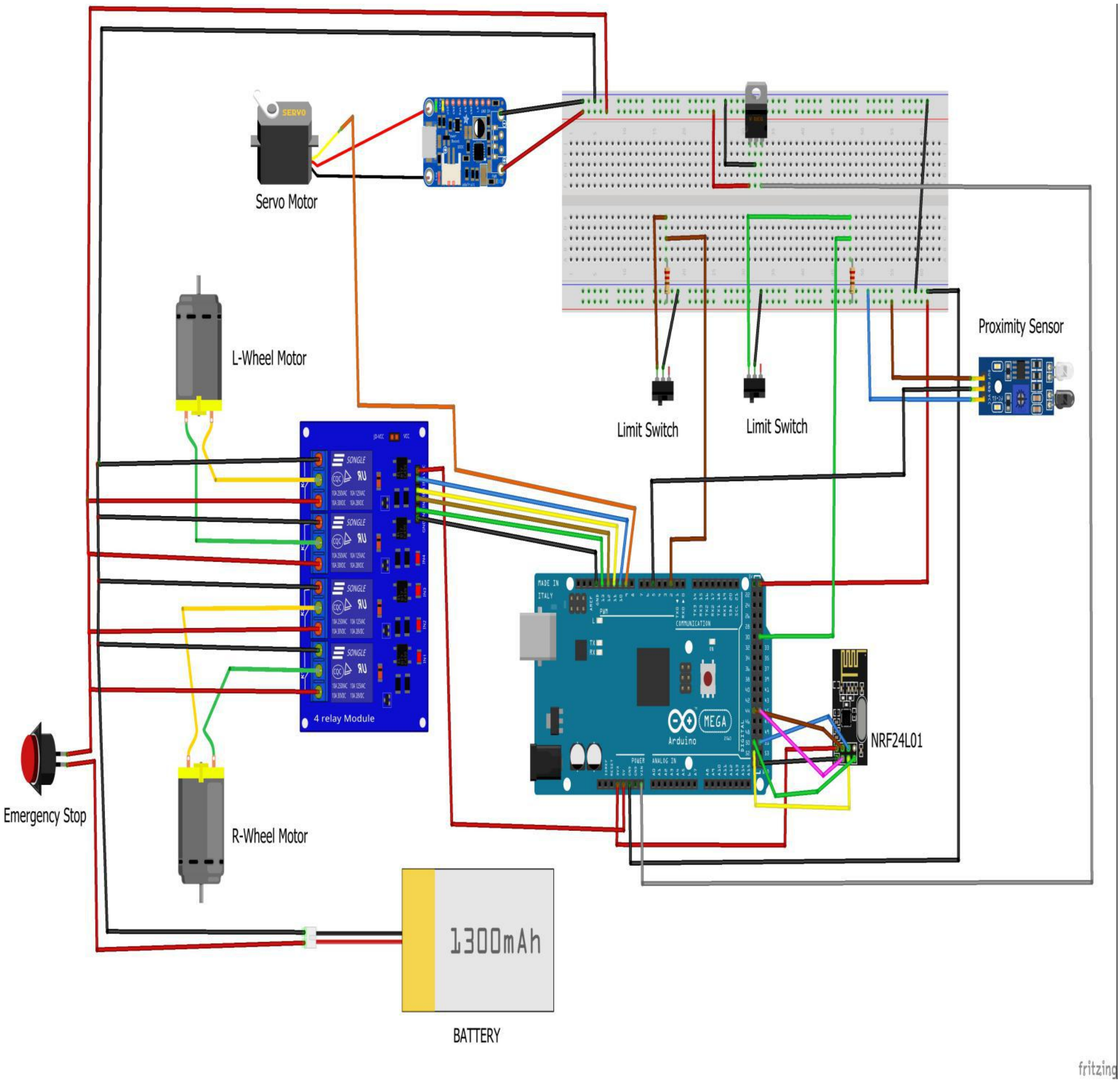


Fig 5-19 : Circuit Schematic of land carriage

5.2 Simulation and Software

5.2.1 Stress Analysis

Shaft Design :

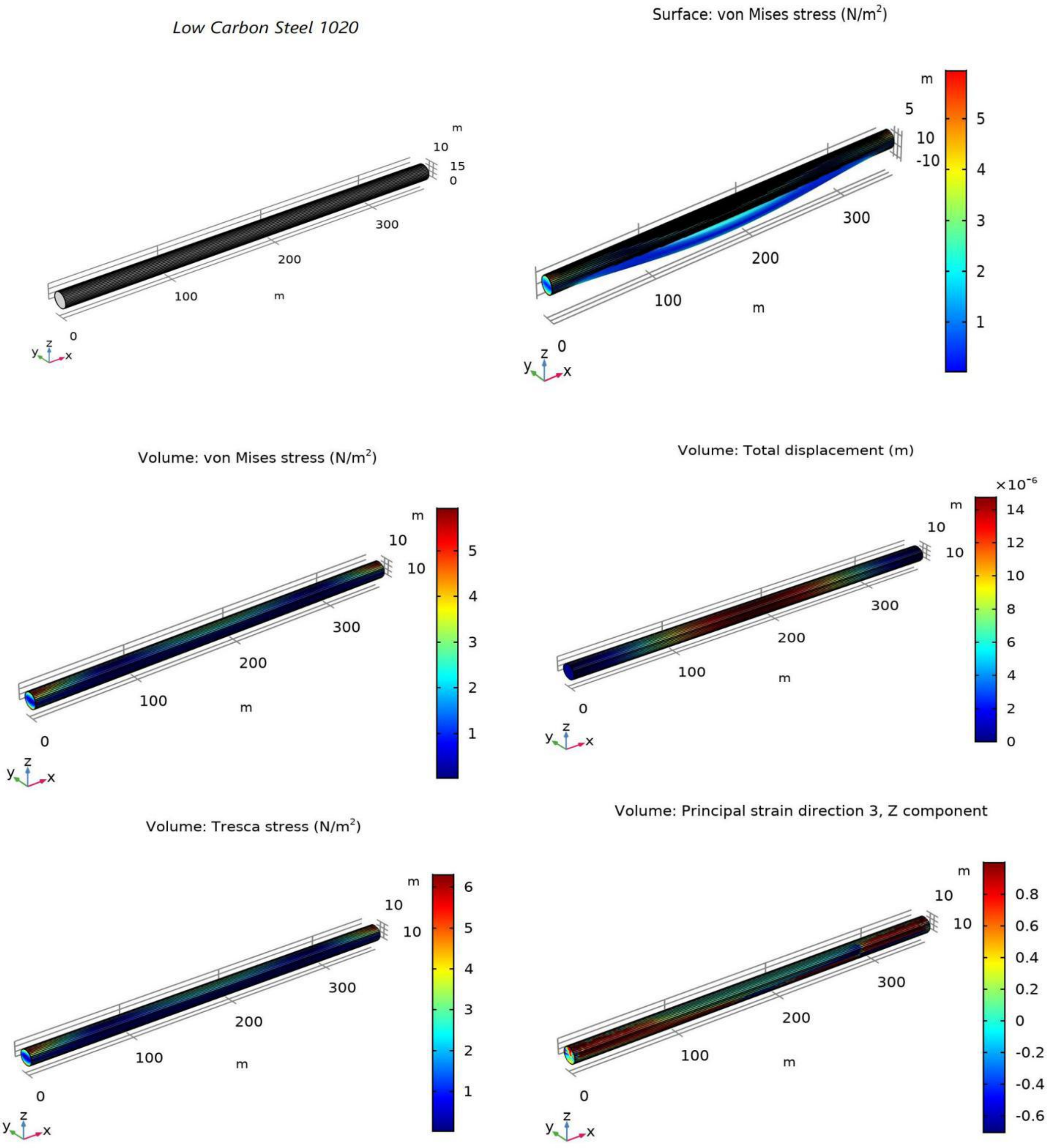


Fig 5-20 : Simulation of Shaft design in comsol

Table Design :

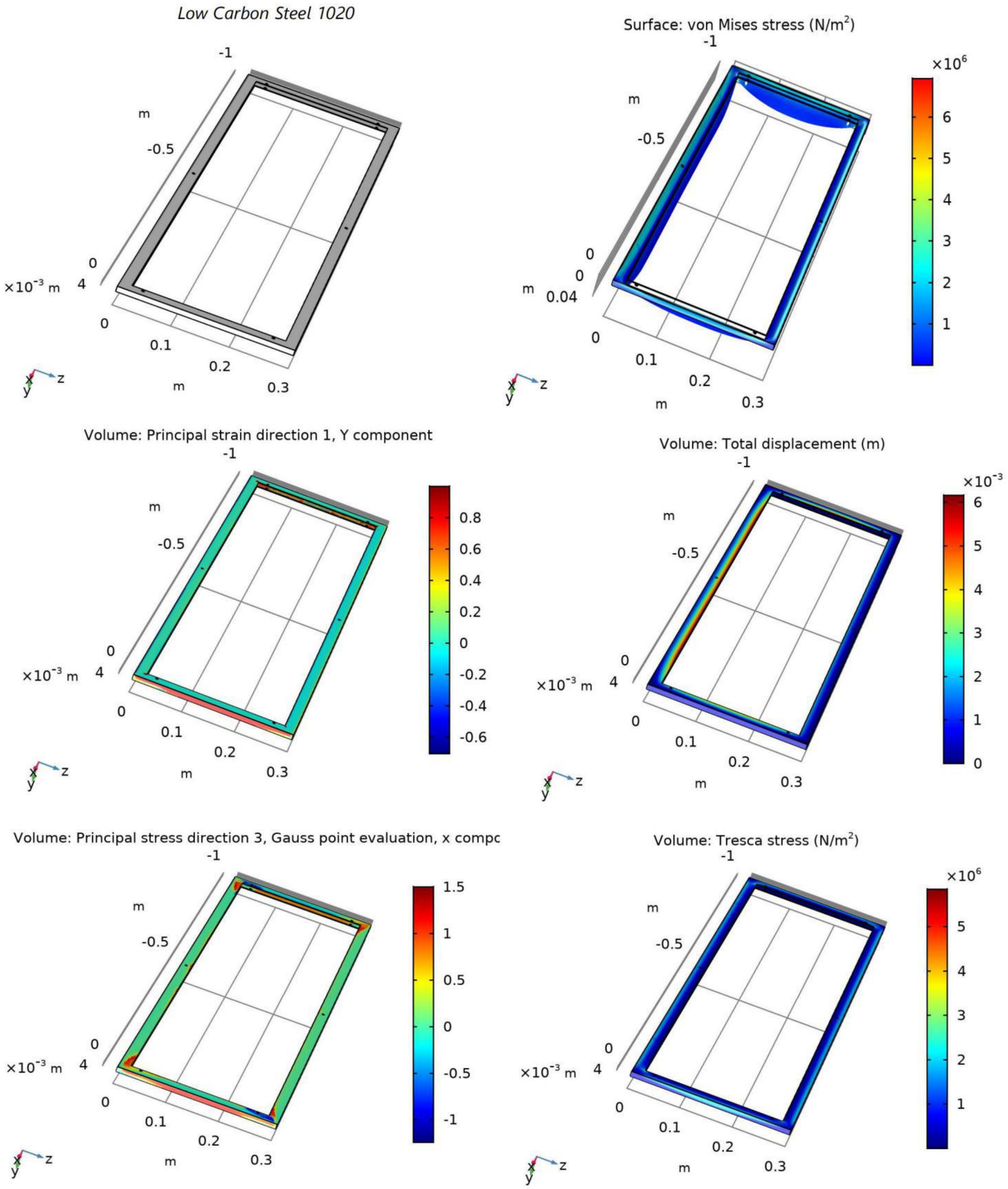


Fig 5-21: Simulation of Table design in comsol

Wheel Design:

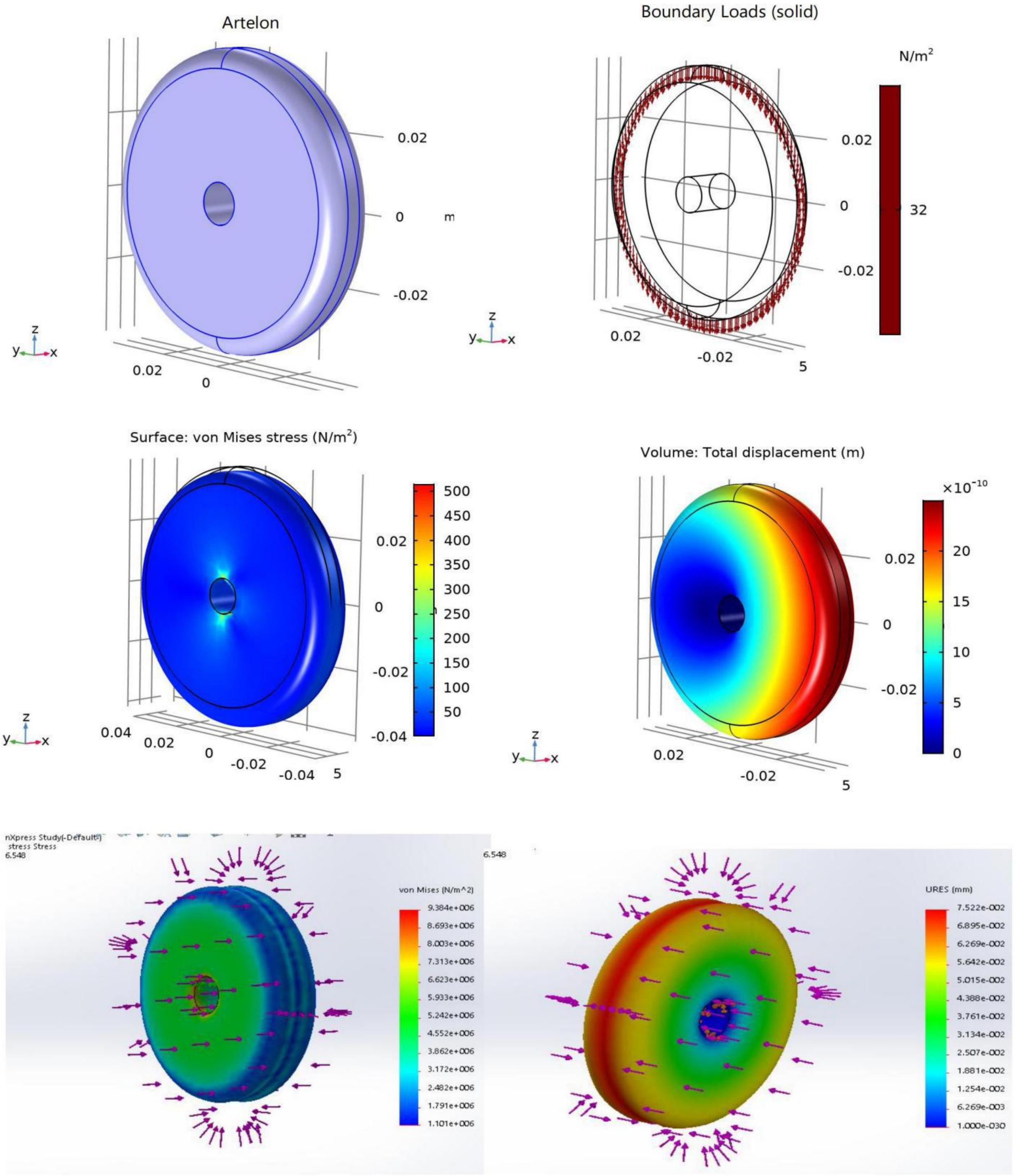


Fig 5-22: Simulation of Wheel design in comsol

Assistant wheel :

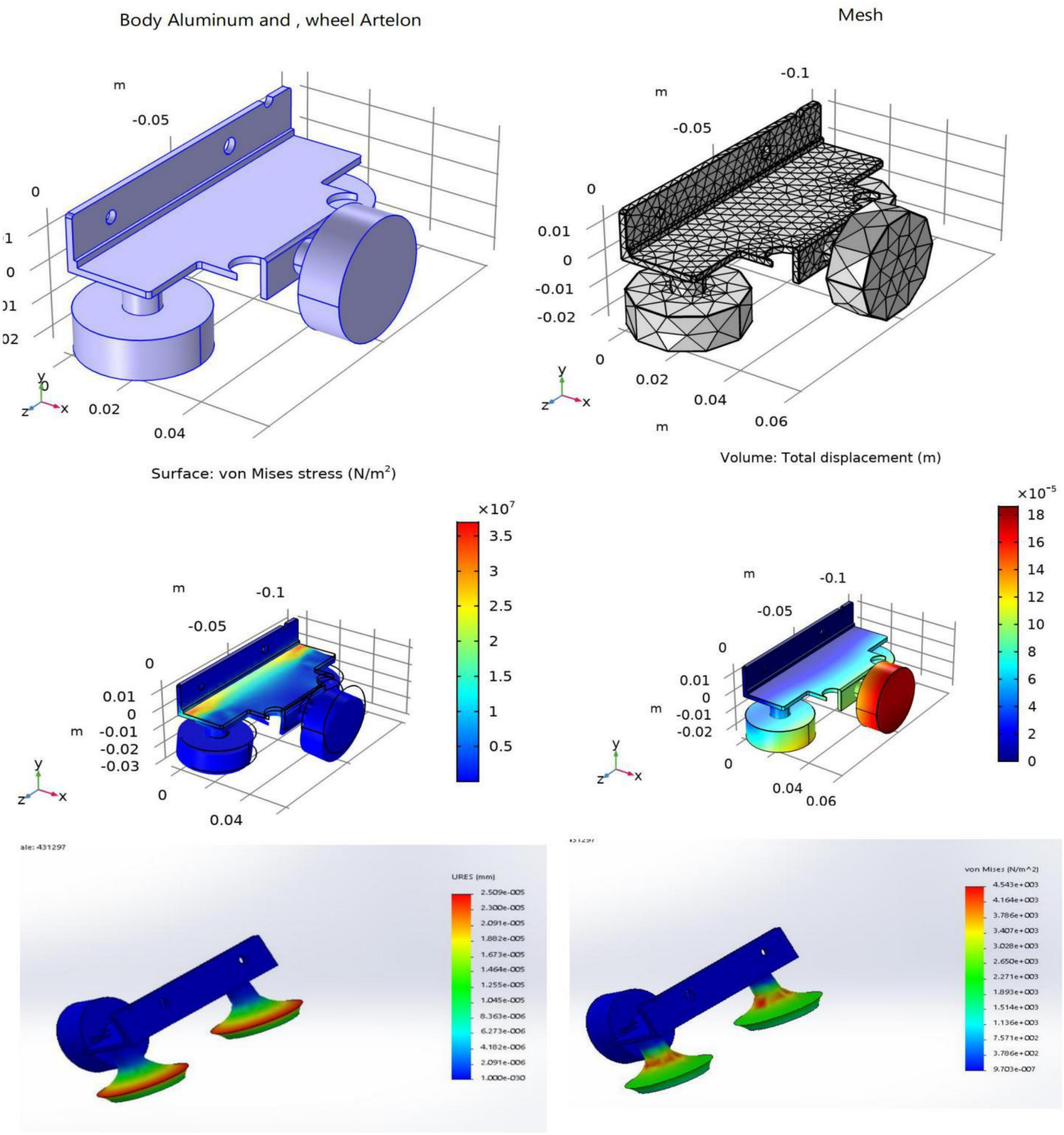


Fig 5-23 : Simulation of Ass. Wheel design in comsol

Sides of cleaning Robot :

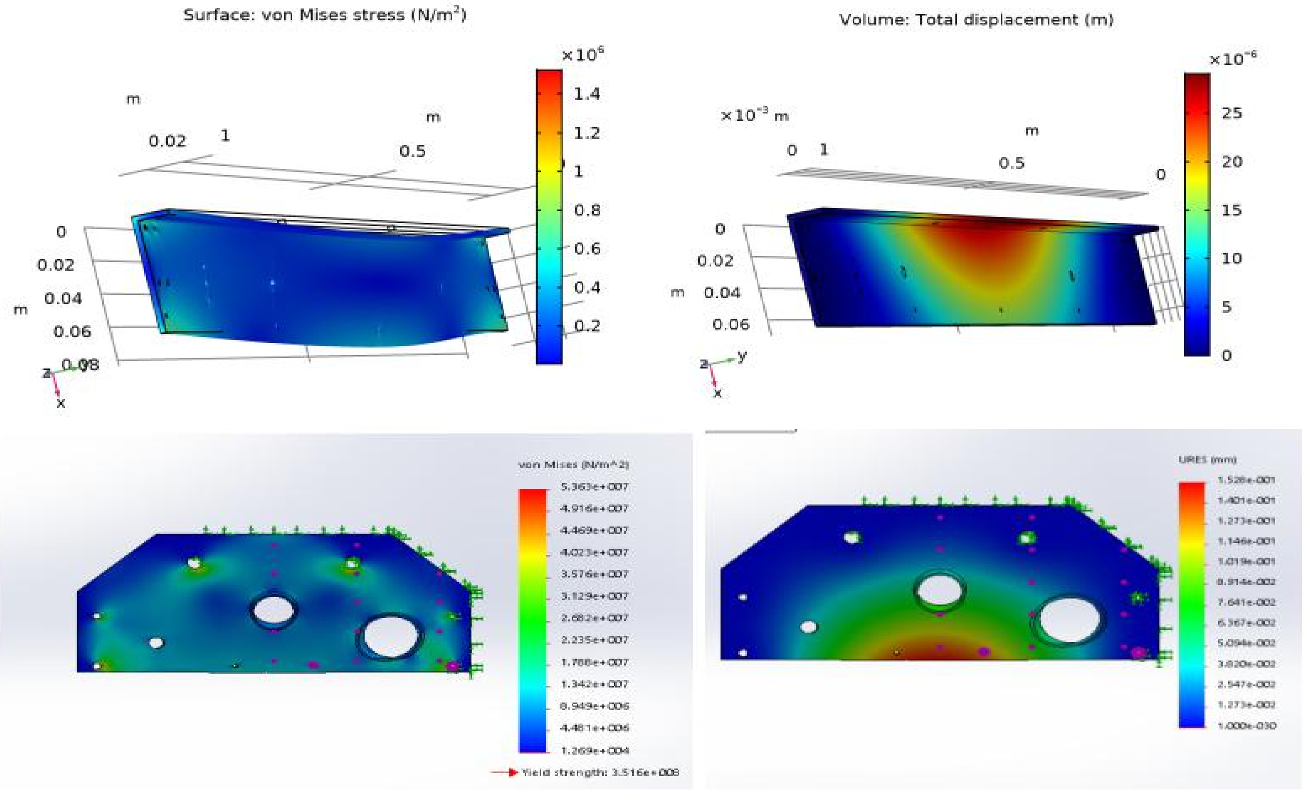


Fig 5-24 : Simulation of Sides design in comsol

Brush design :

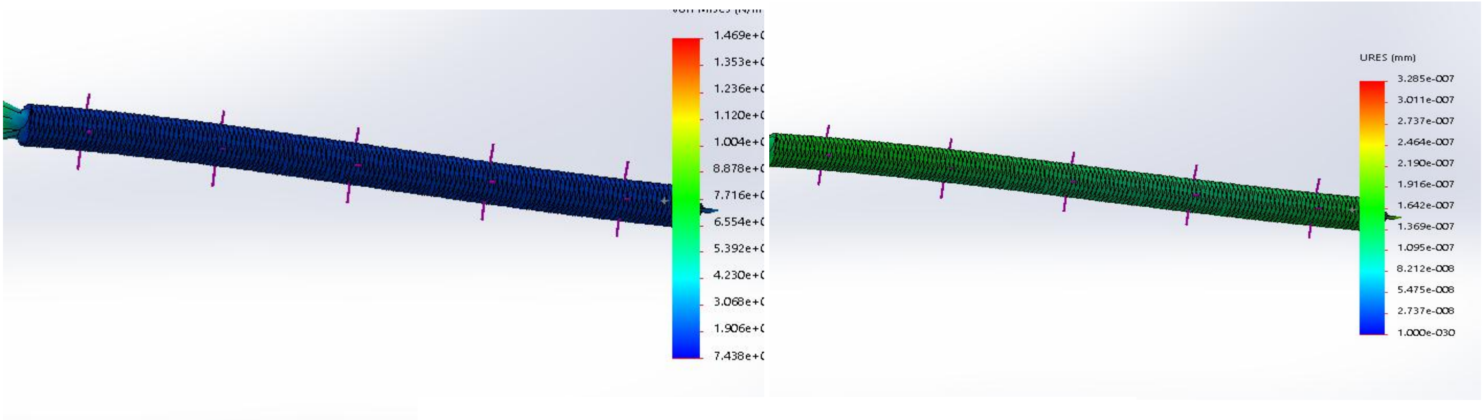


Fig 5-25 : Simulation of brush in Solidwork

Installation assistant:

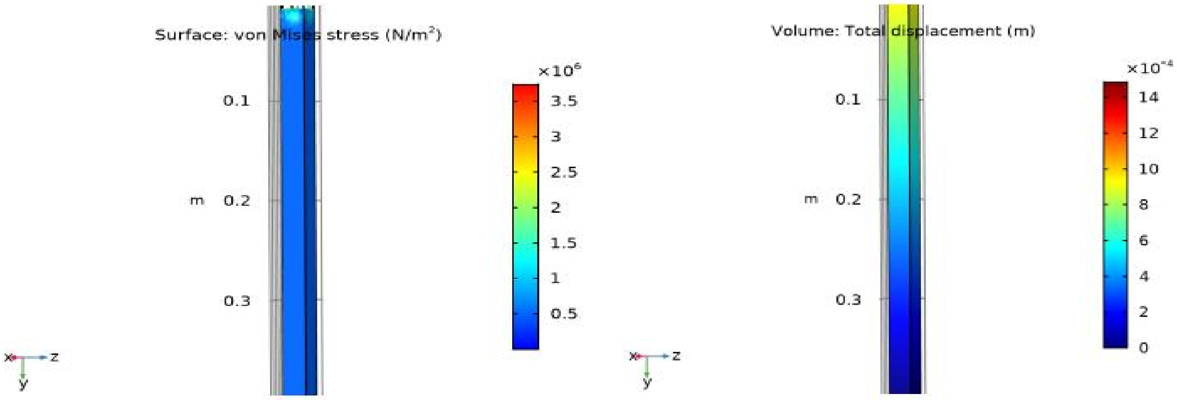


Fig 5-26 : Simulation of Installation ass. in Comsol

Base :

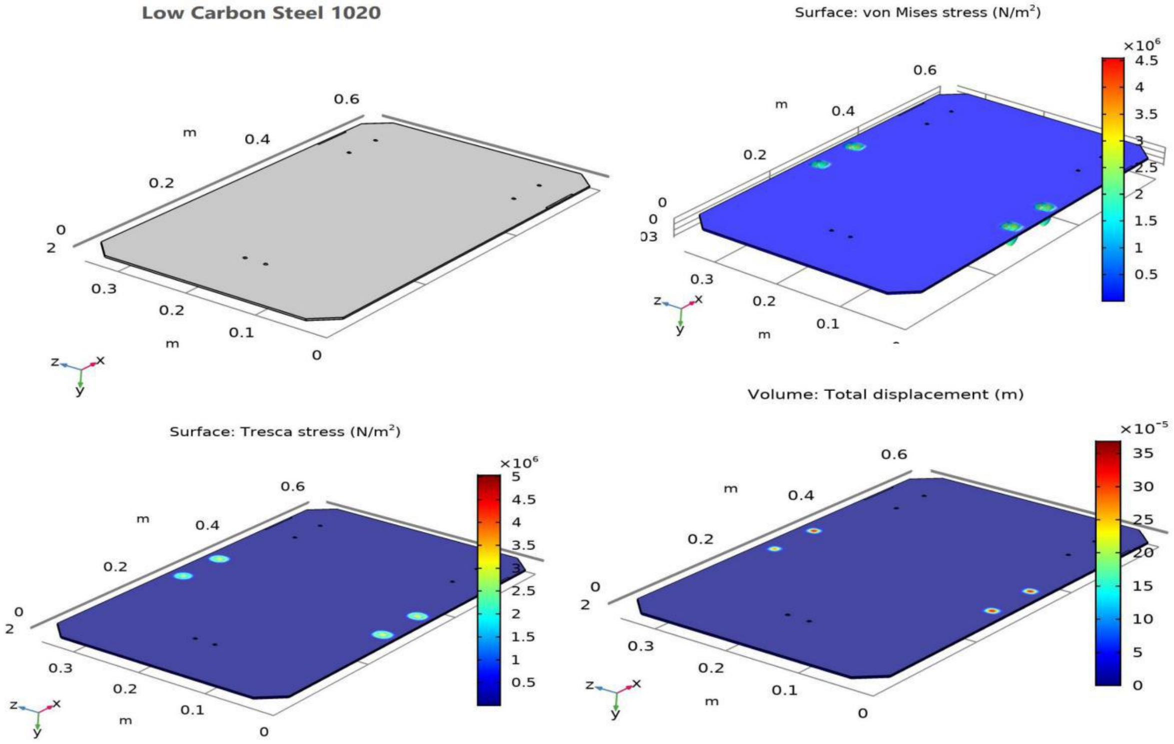


Fig 5-27 : Simulation of Base in Comsol

Aerodynamics

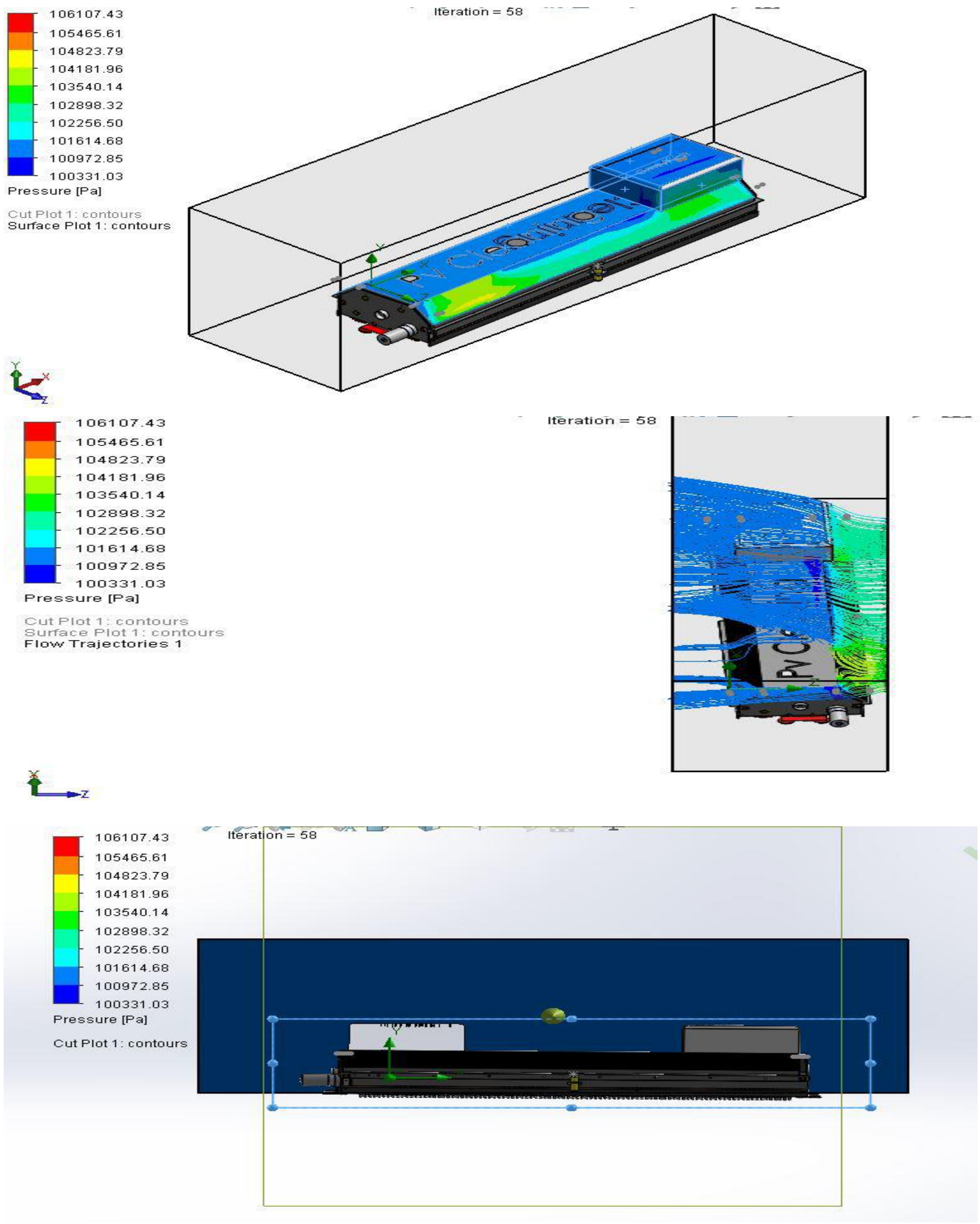
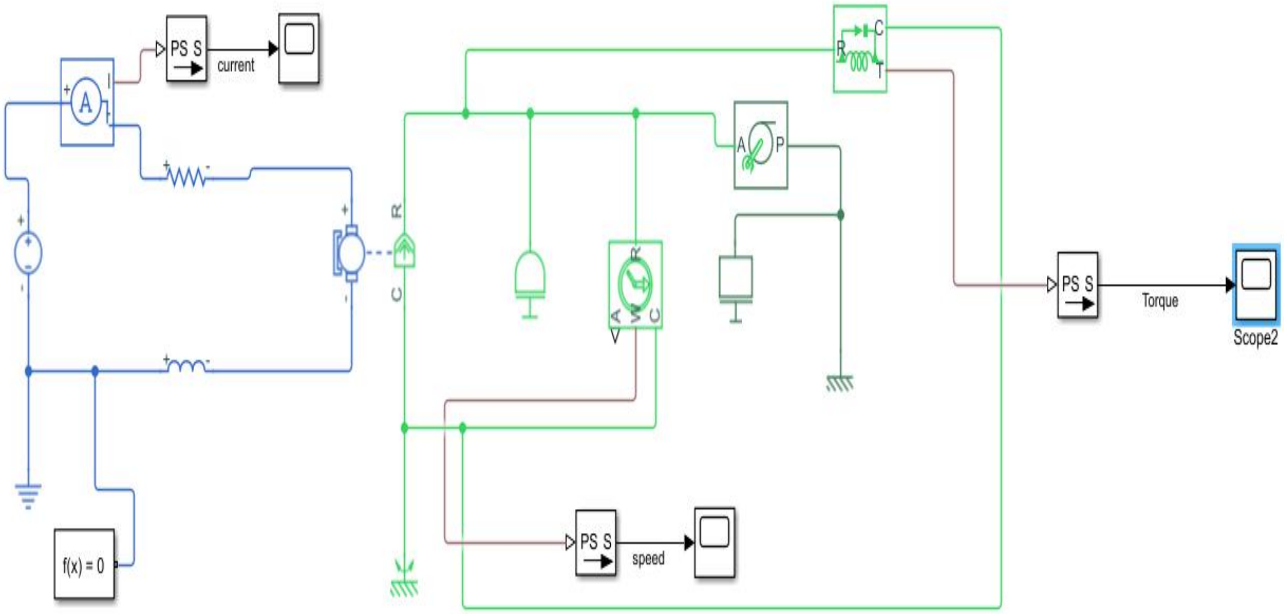


Fig 5-28 : Aerodynamics of the cover

5.2.2 Matlab simulation for DC motor:-

Simscap model of DC motor



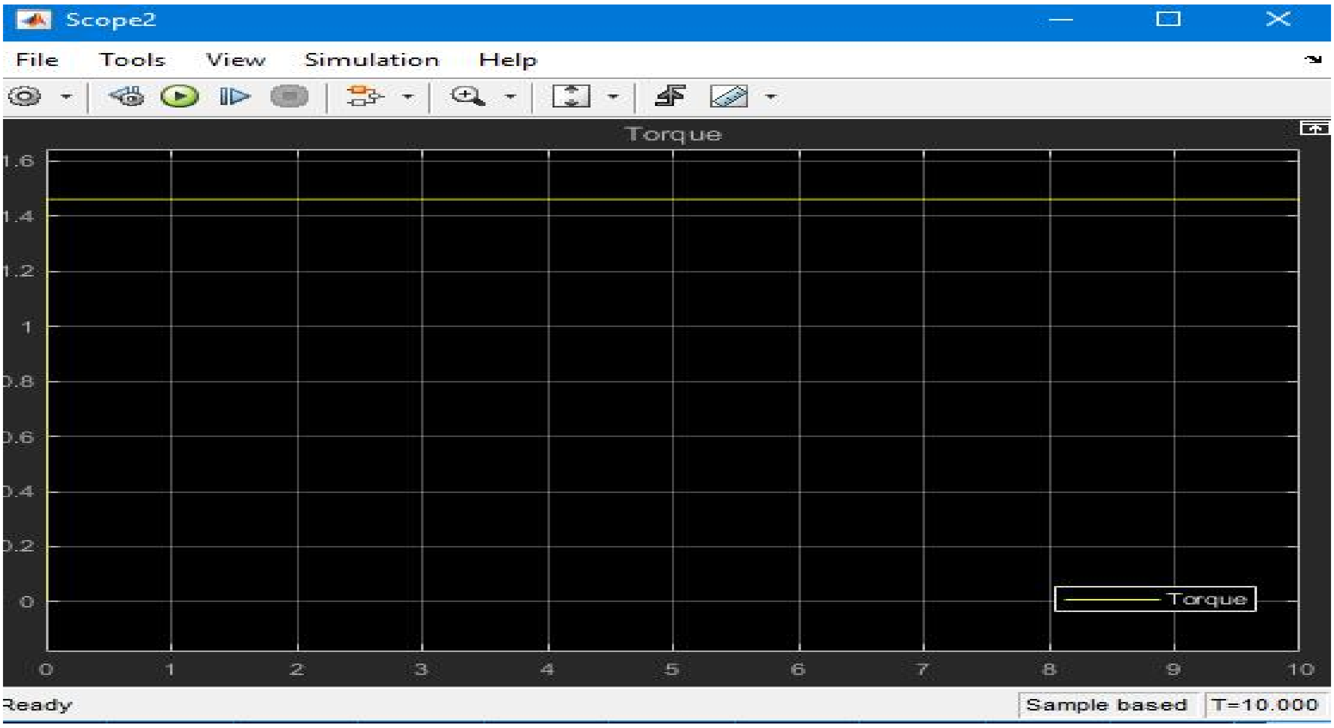
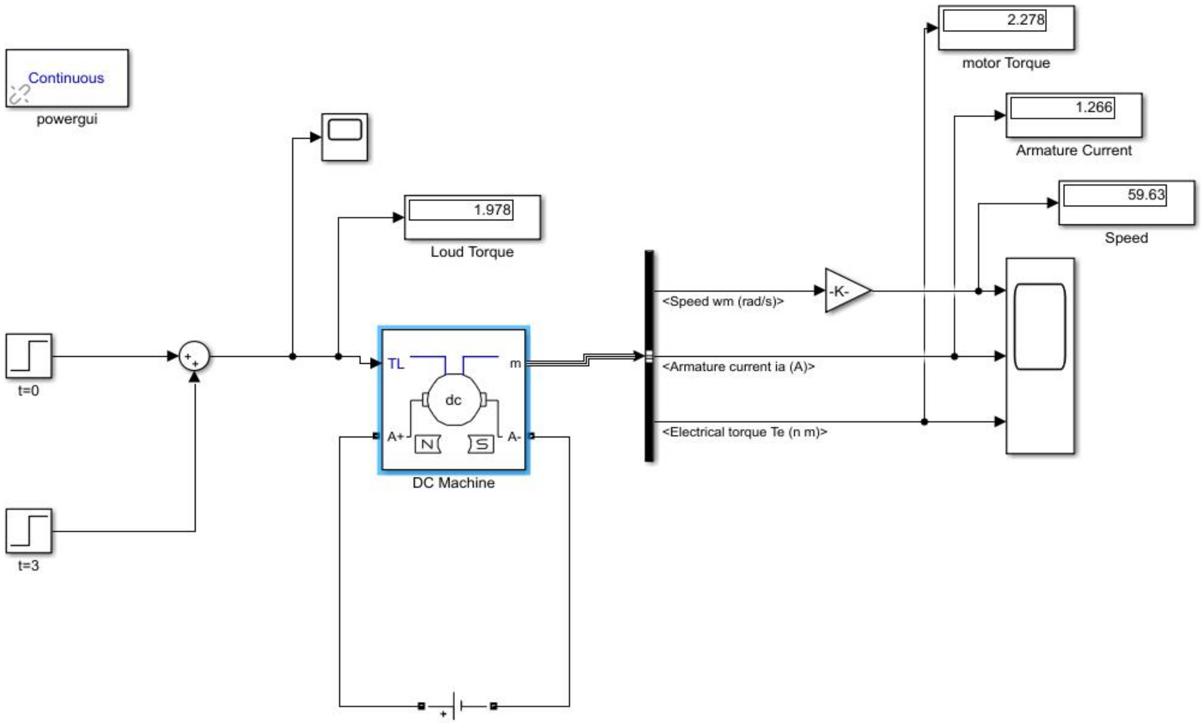


Fig 5-29 : simscap model of DC Motor in matlab with Result (N.m)

Simulation of Cleaning Robot DC Motor :



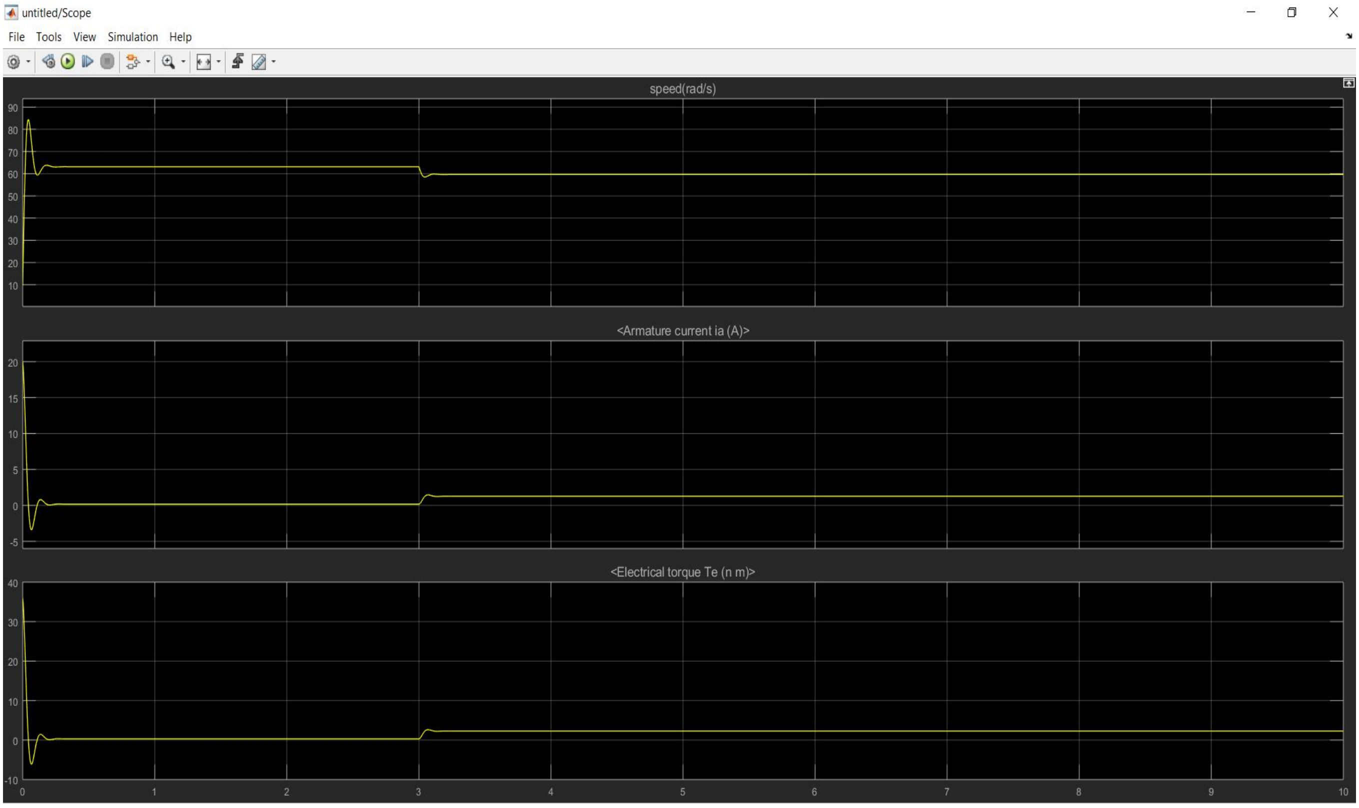
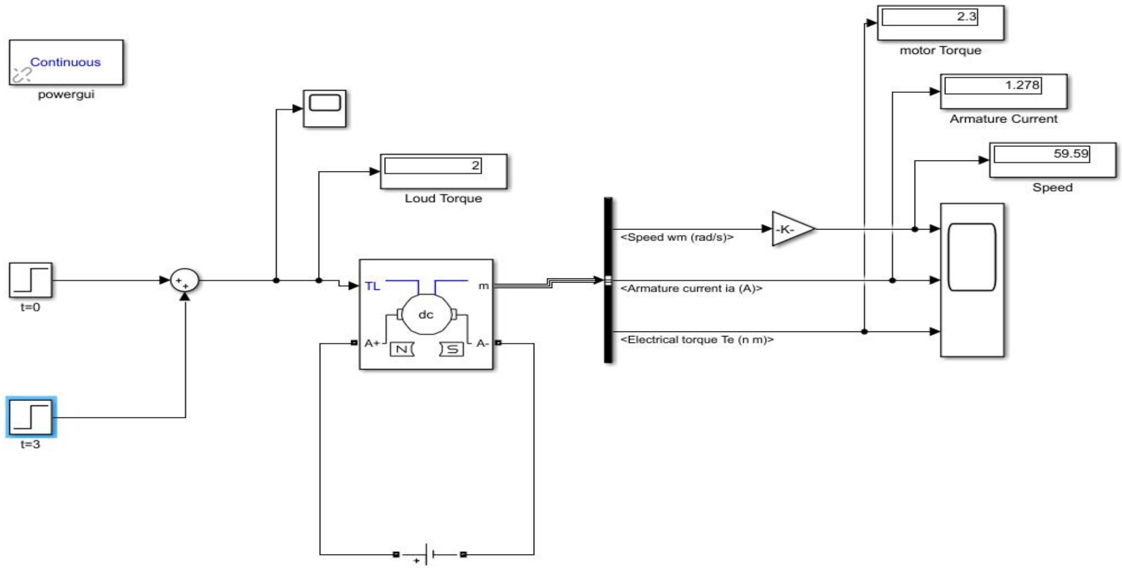


Fig 5-30 : simulation of Cleaning Robot DC Motor in matlab with Result

Simulation of Land Carriage DC Motor :



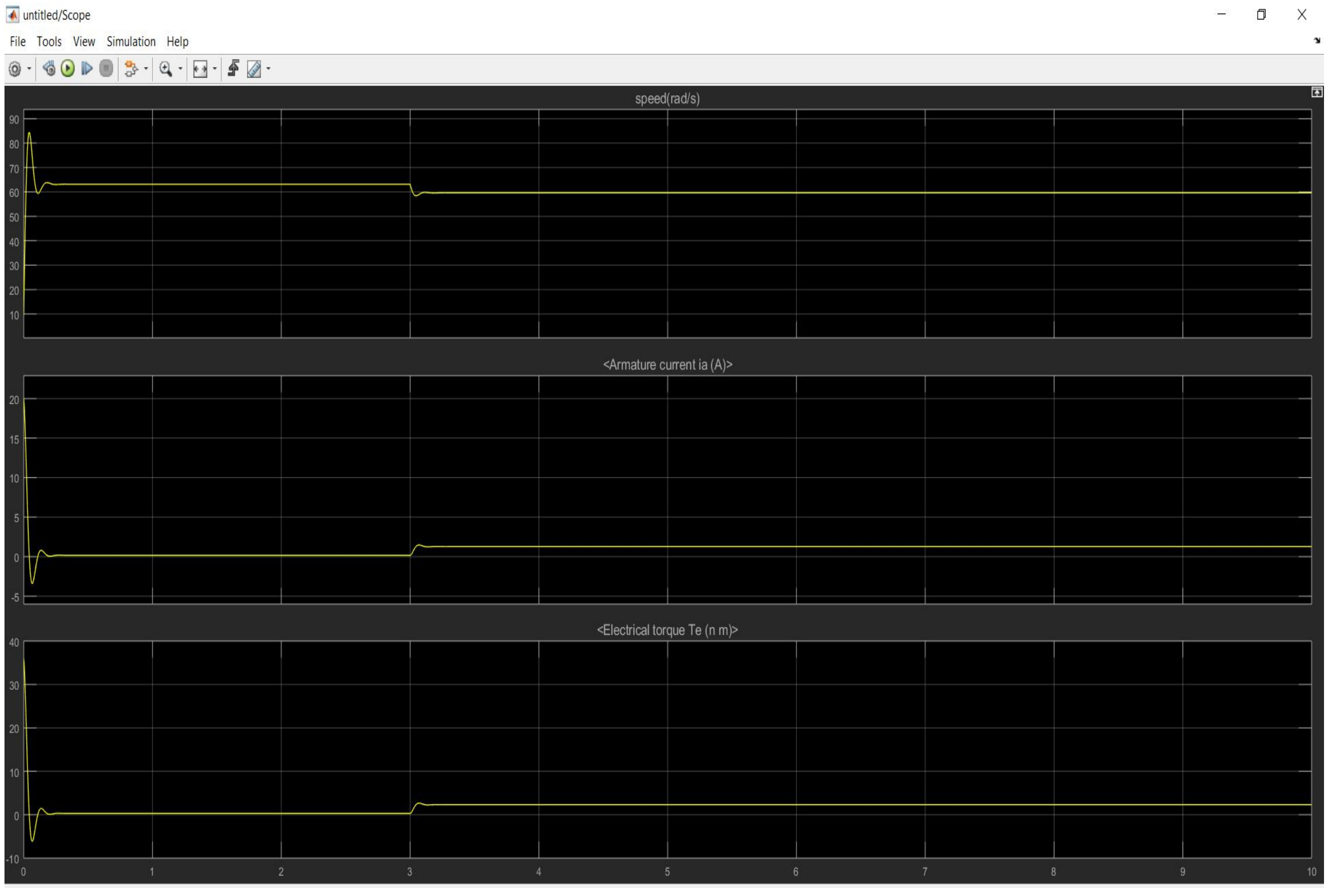

untitled/Scope
File Tools View Simulation Help
speed(rad/s)
90
80
70
60
50
40
30
20
10
<Armature current ia (A)>
20
15
10
5
0
-5
<Electrical torque Te (n m)>
40
30
20
10
0
-10
0
1
2
3
4
5
6
7
8
9
10

Fig 5-31 : simulation of Land Carriage DC Motor in matlab with Result

5.2.3 Electrical Simulation :

Cleaning Robot Electrical Simulation

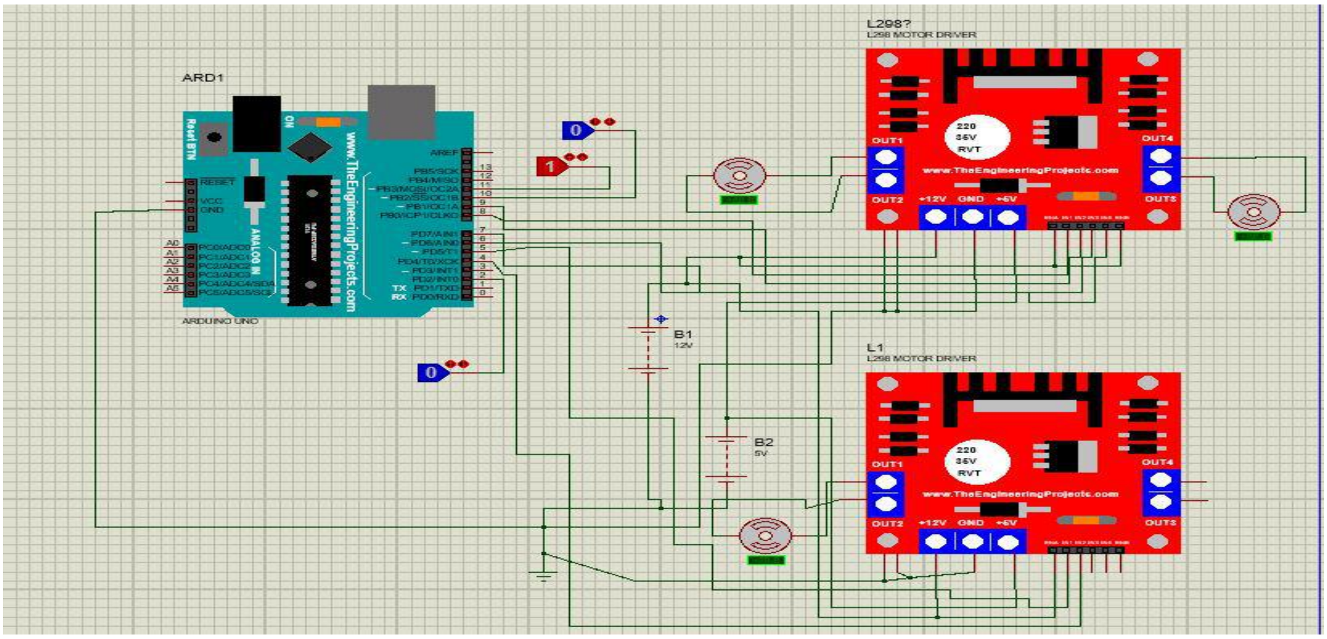


Fig 5-32 : Electrical simulation of cleaning robot in proteus

Land Carriage Simulation

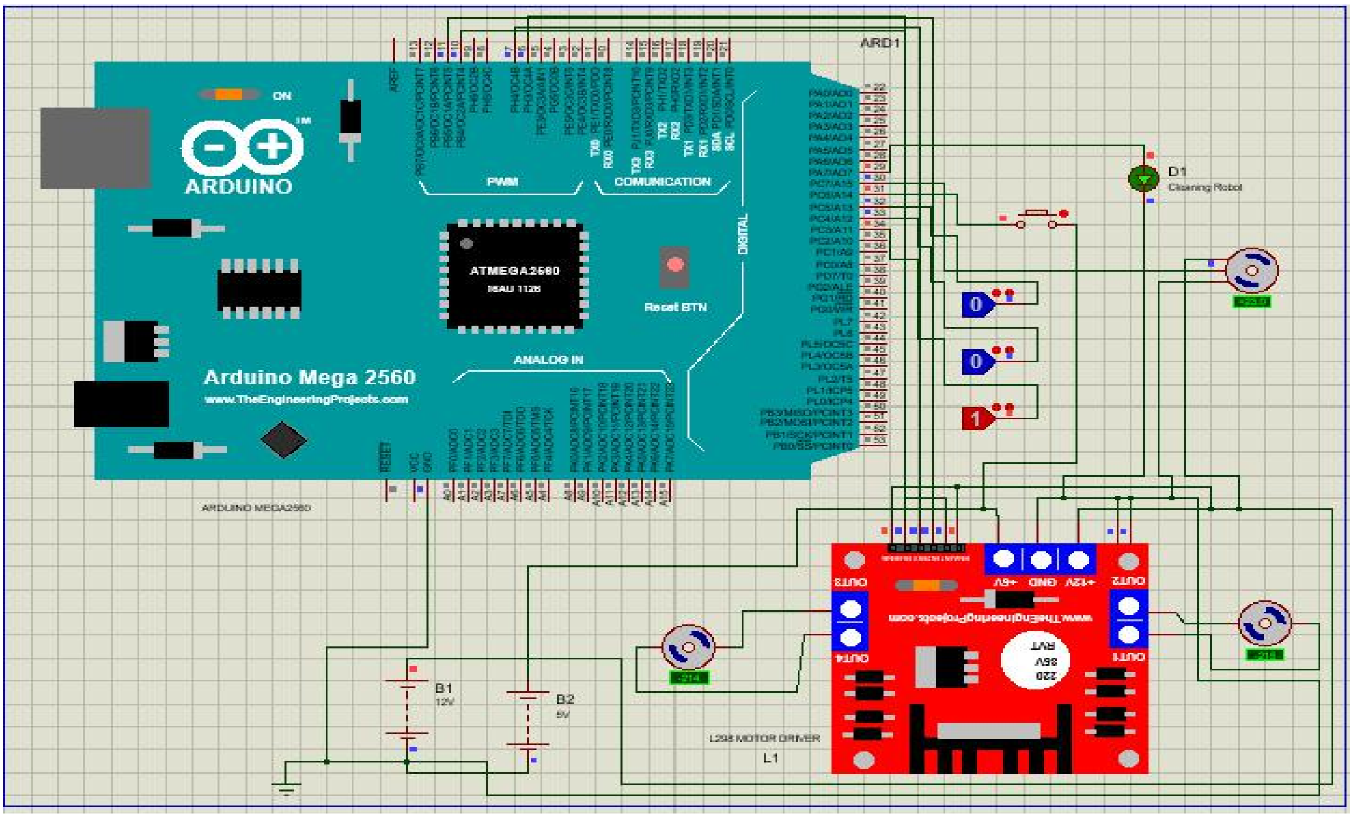


Fig 5-33 : Electrical simulation for Land Robot in proteus

5.2.4 Coding :

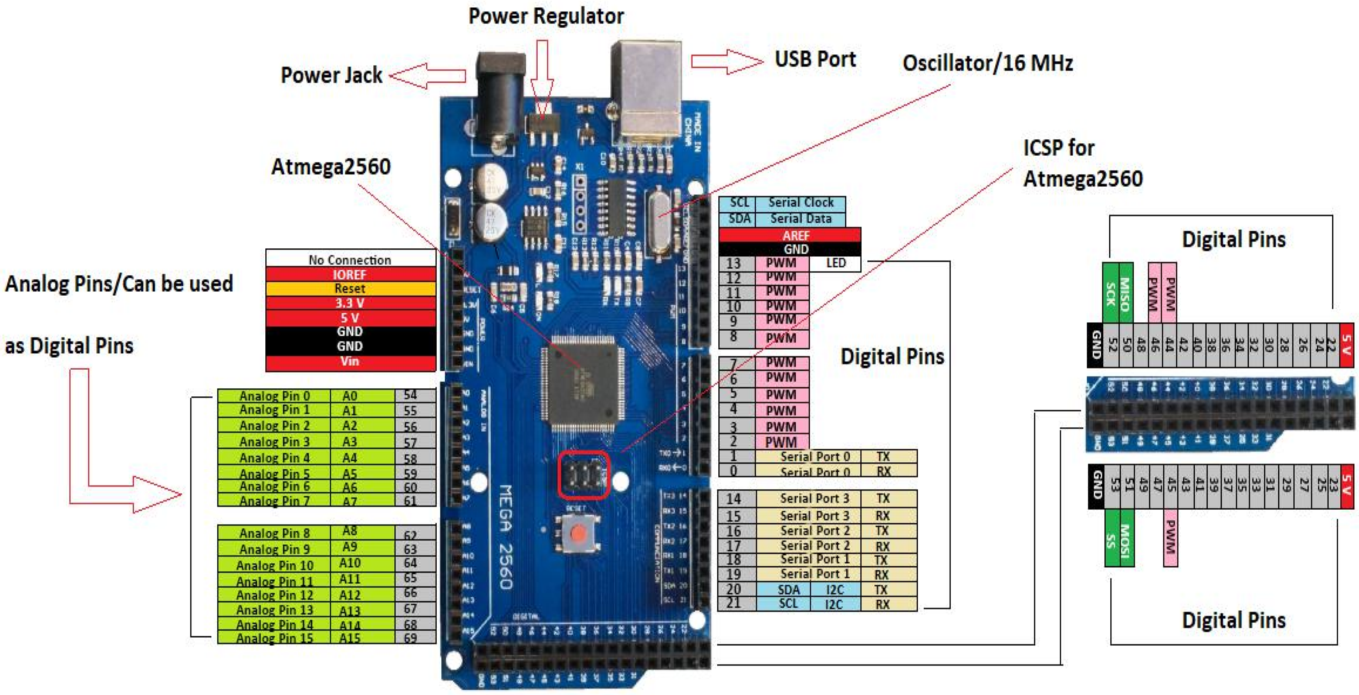
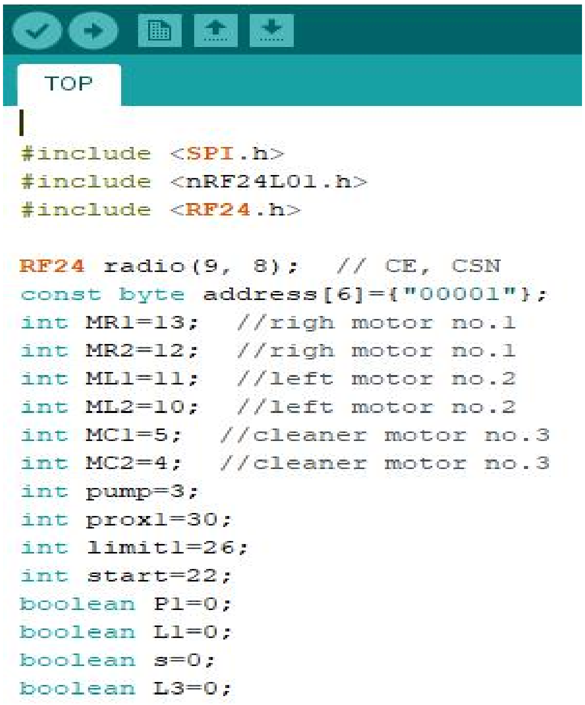


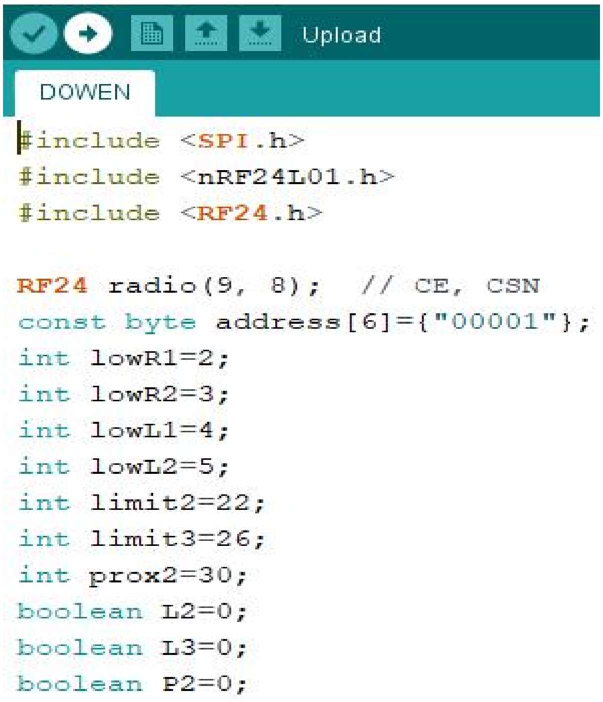
Fig 5-34 : Arduino Mega

Cleaning Robot Code



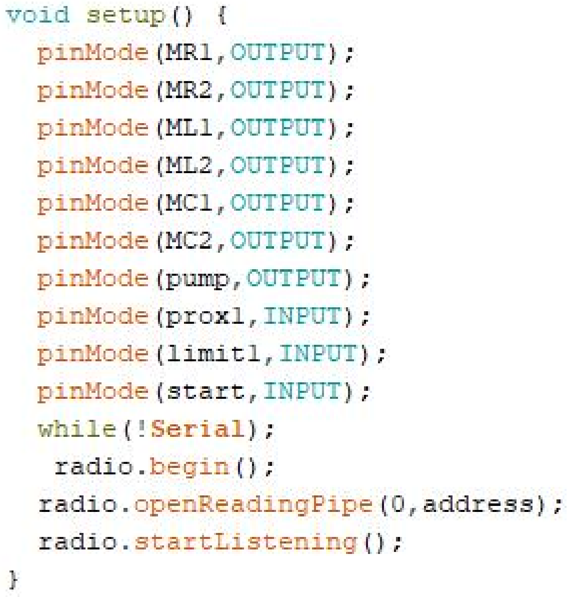
```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>

RF24 radio(9, 8);  // CE, CSN
const byte address[6]={"00001"};
int MR1=13;  //righ motor no.1
int MR2=12;  //righ motor no.1
int ML1=11;  //left motor no.2
int ML2=10;  //left motor no.2
int MC1=5;  //cleaner motor no.3
int MC2=4;  //cleaner motor no.3
int pump=3;
int prox1=30;
int limit1=26;
int start=22;
boolean P1=0;
boolean L1=0;
boolean s=0;
boolean L3=0;
```

Land Carriage

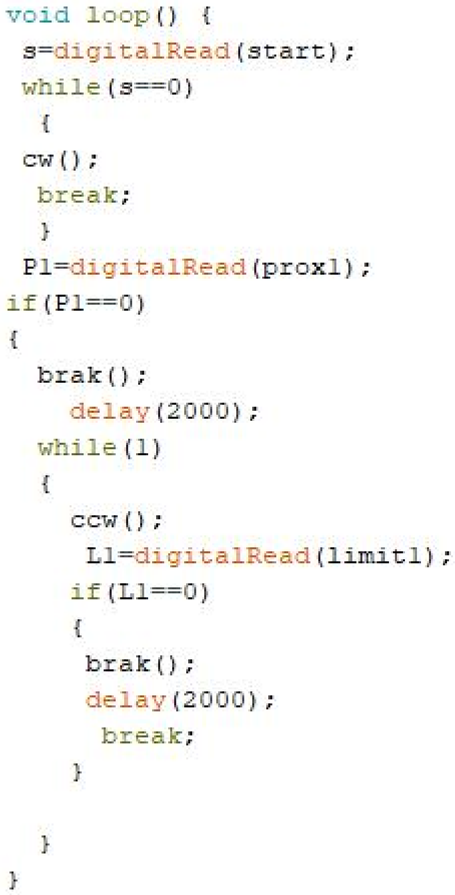


```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>

RF24 radio(9, 8);  // CE, CSN
const byte address[6]={"00001"};
int lowR1=2;
int lowR2=3;
int lowL1=4;
int lowL2=5;
int limit2=22;
int limit3=26;
int prox2=30;
boolean L2=0;
boolean L3=0;
boolean P2=0;
```

Cleaning Robot Code

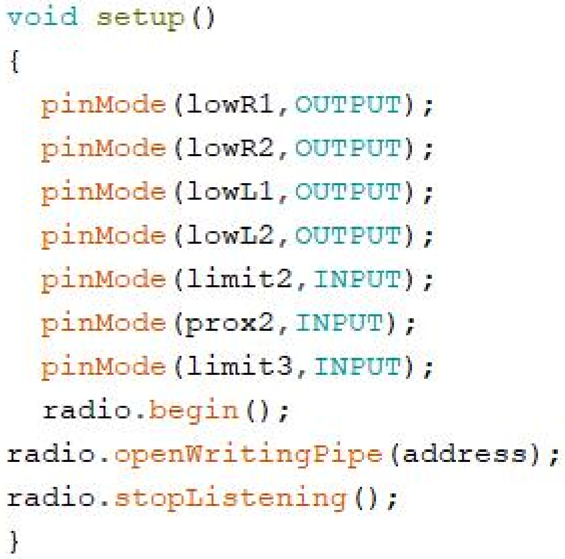


```
void setup() {
  pinMode(MR1,OUTPUT);
  pinMode(MR2,OUTPUT);
  pinMode(ML1,OUTPUT);
  pinMode(ML2,OUTPUT);
  pinMode(MC1,OUTPUT);
  pinMode(MC2,OUTPUT);
  pinMode(pump,OUTPUT);
  pinMode(prox1,INPUT);
  pinMode(limit1,INPUT);
  pinMode(start,INPUT);
  while(!Serial);
   radio.begin();
  radio.openReadingPipe(0,address);
  radio.startListening();
}
```

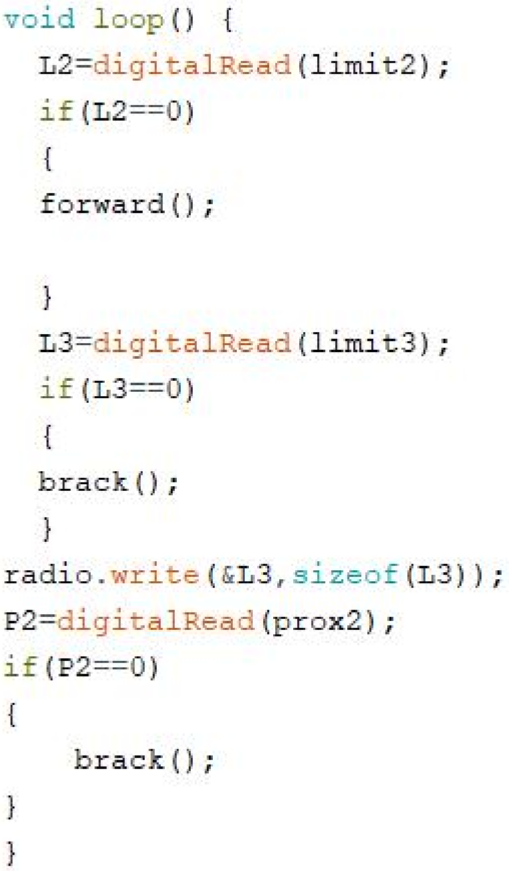


```
void loop() {
 s=digitalRead(start);
 while(s==0)
  {
 cw();
  break;
  }
 P1=digitalRead(prox1);
if(P1==0)
{
  brak();
    delay(2000);
  while(1)
  {
    ccw();
     L1=digitalRead(limit1);
    if(L1==0)
    {
     brak();
     delay(2000);
      break;
    }

  }
}
```

Land Carriage

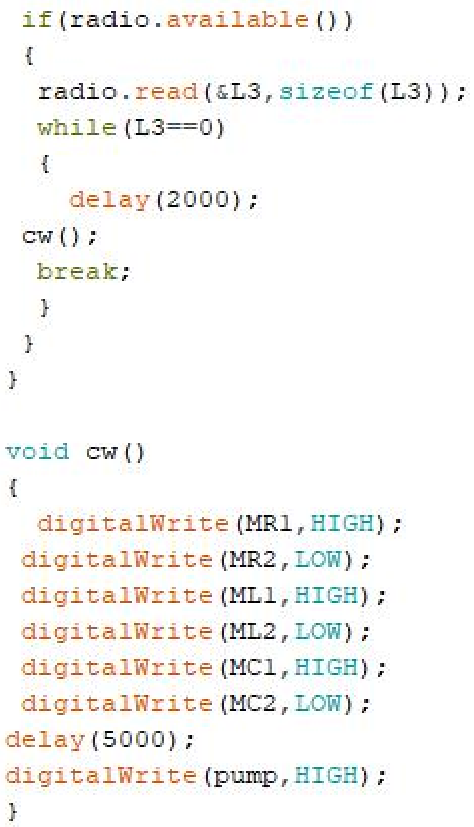


```
void setup()
{
  pinMode(lowR1,OUTPUT);
  pinMode(lowR2,OUTPUT);
  pinMode(lowL1,OUTPUT);
  pinMode(lowL2,OUTPUT);
  pinMode(limit2,INPUT);
  pinMode(prox2,INPUT);
  pinMode(limit3,INPUT);
  radio.begin();
radio.openWritingPipe(address);
radio.stopListening();
}
```

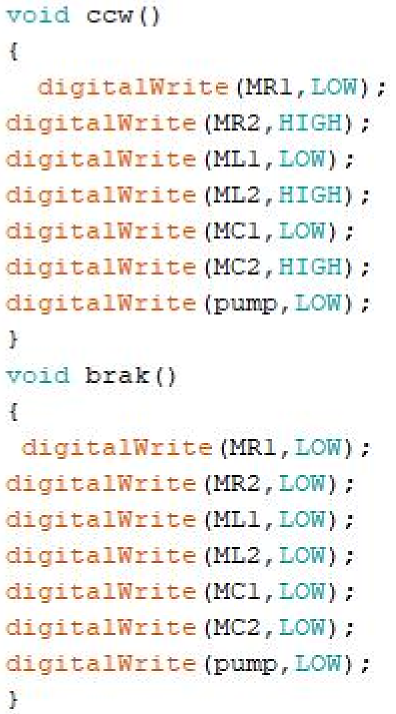


```
void loop() {
  L2=digitalRead(limit2);
  if(L2==0)
  {
  forward();

  }
  L3=digitalRead(limit3);
  if(L3==0)
  {
  brack();
  }
radio.write(&L3,sizeof(L3));
P2=digitalRead(prox2);
if(P2==0)
{
    brack();
}
}
```

Cleaning Robot Code

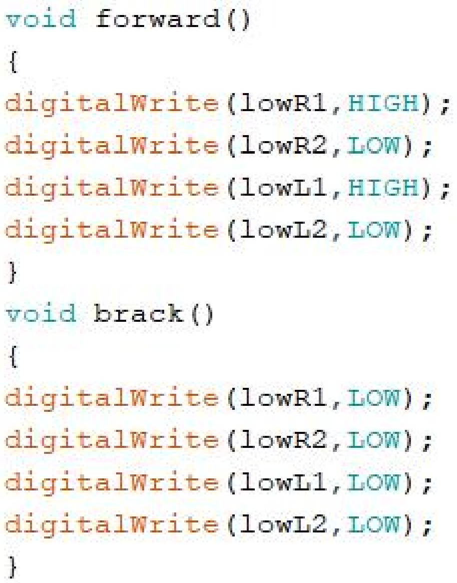


```
 if(radio.available())
 {
  radio.read(&L3,sizeof(L3));
  while(L3==0)
  {
    delay(2000);
 cw();
  break;
  }
 }
}

void cw()
{
  digitalWrite(MR1,HIGH);
 digitalWrite(MR2,LOW);
 digitalWrite(ML1,HIGH);
 digitalWrite(ML2,LOW);
 digitalWrite(MC1,HIGH);
 digitalWrite(MC2,LOW);
delay(5000);
digitalWrite(pump,HIGH);
}
```



```
void ccw()
{
  digitalWrite(MR1,LOW);
digitalWrite(MR2,HIGH);
digitalWrite(ML1,LOW);
digitalWrite(ML2,HIGH);
digitalWrite(MC1,LOW);
digitalWrite(MC2,HIGH);
digitalWrite(pump,LOW);
}
void brak()
{
 digitalWrite(MR1,LOW);
digitalWrite(MR2,LOW);
digitalWrite(ML1,LOW);
digitalWrite(ML2,LOW);
digitalWrite(MC1,LOW);
digitalWrite(MC2,LOW);
digitalWrite(pump,LOW);
}
```

Land Carriage



```
void forward()
{
digitalWrite(lowR1,HIGH);
digitalWrite(lowR2,LOW);
digitalWrite(lowL1,HIGH);
digitalWrite(lowL2,LOW);
}
void brack()
{
digitalWrite(lowR1,LOW);
digitalWrite(lowR2,LOW);
digitalWrite(lowL1,LOW);
digitalWrite(lowL2,LOW);
}
```

5.3 Implementation

5.3.1 Manufacture of a cleaning Robot :

It is made of 3mm thickness aluminum sheet

It is cut by a laser machine for precision, because its thickness is small

And use the Bending CNC to make the cover shape and fold the sides

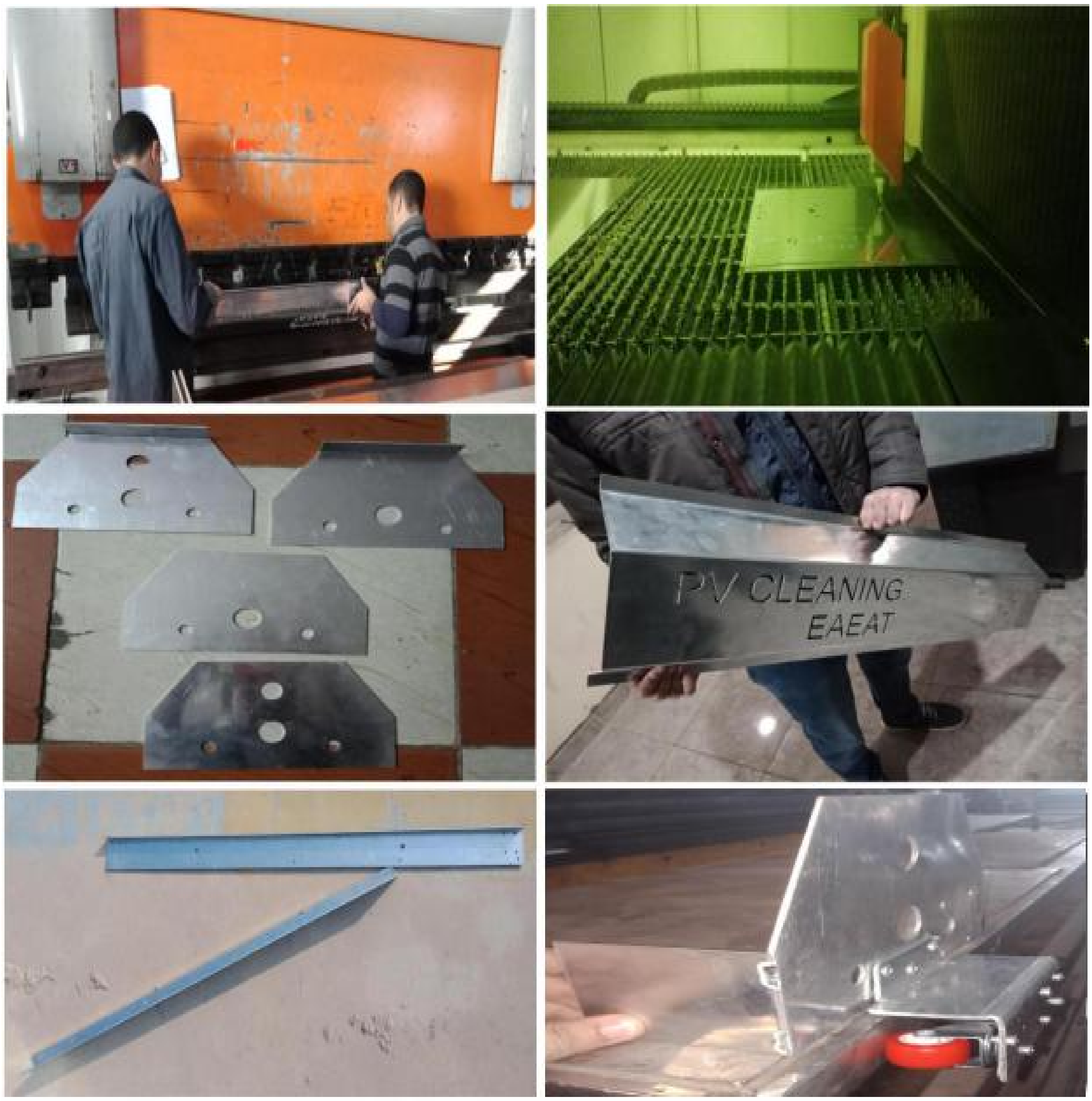


Fig 5-35 : Manufacture of a cleaning Robot

5.3.2 Manufacture of Wheel and Brush :

Wheel are made of Artillon using a lathe :

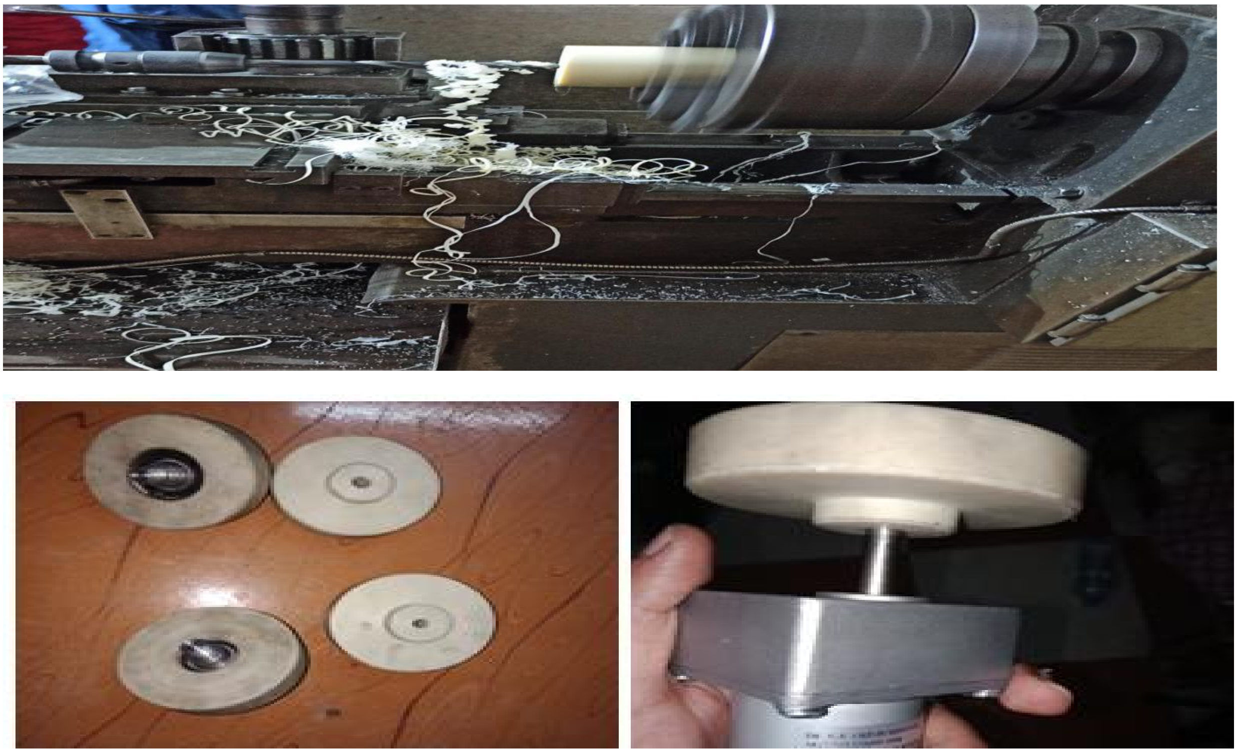


Fig 5-36 : Manufacture of Wheel

Brush pole are made of Artillon using a lathe and The cleaning brush is made of a soft synthetic fiber material in order not to scratch the panels and not absorb the fluids

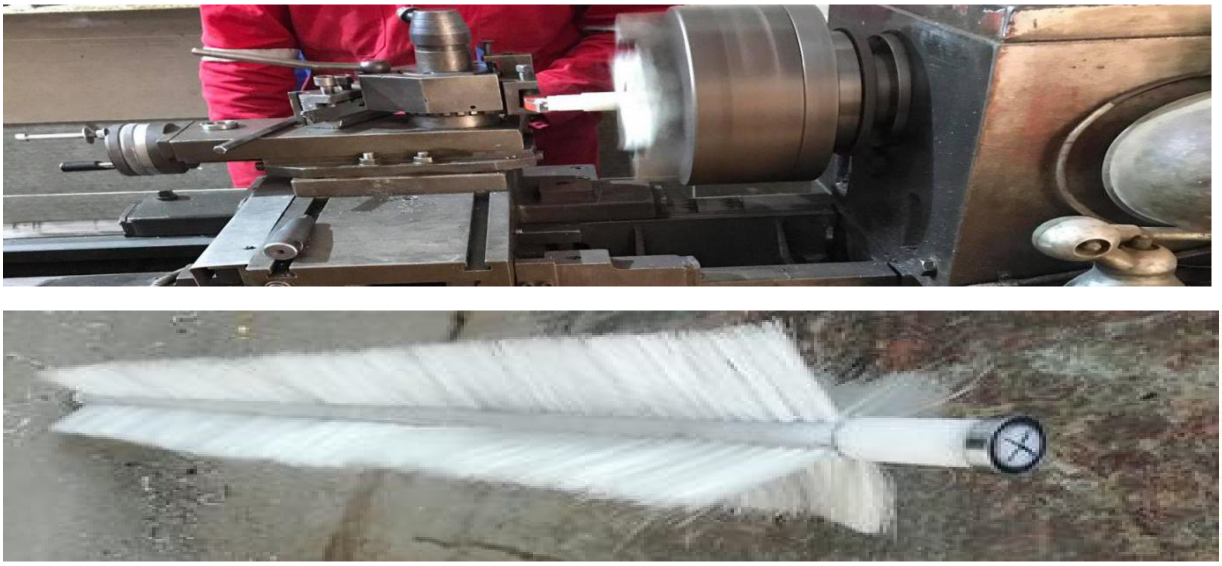


Fig 5-37 : Manufacture of Brush

5.3.3 Manufacture of land carriage :

It is made of steel, assembled with welding and cut with a plasma machine

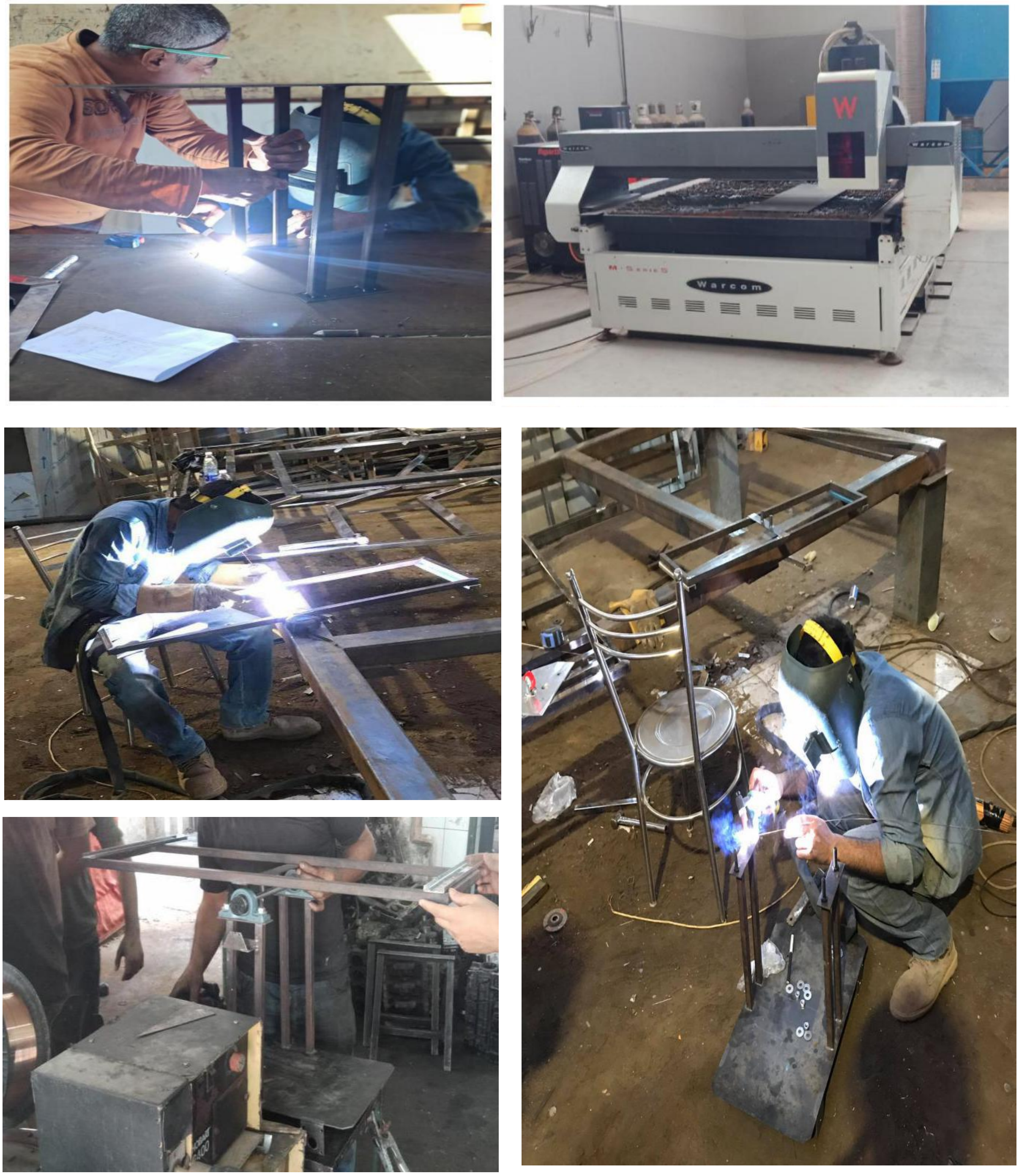


Fig 5-38 : Manufacture of Land Carriage

Cover

Made from wood

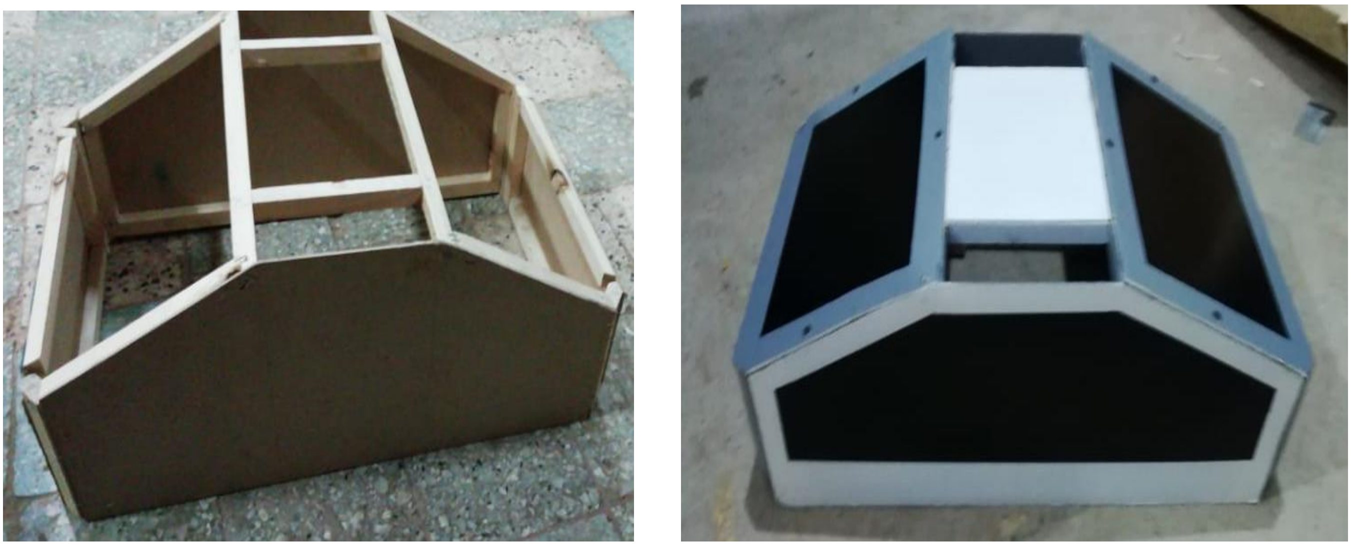


Fig 5-38 : Manufacture of Land Carriage Cover

Assembly of Project

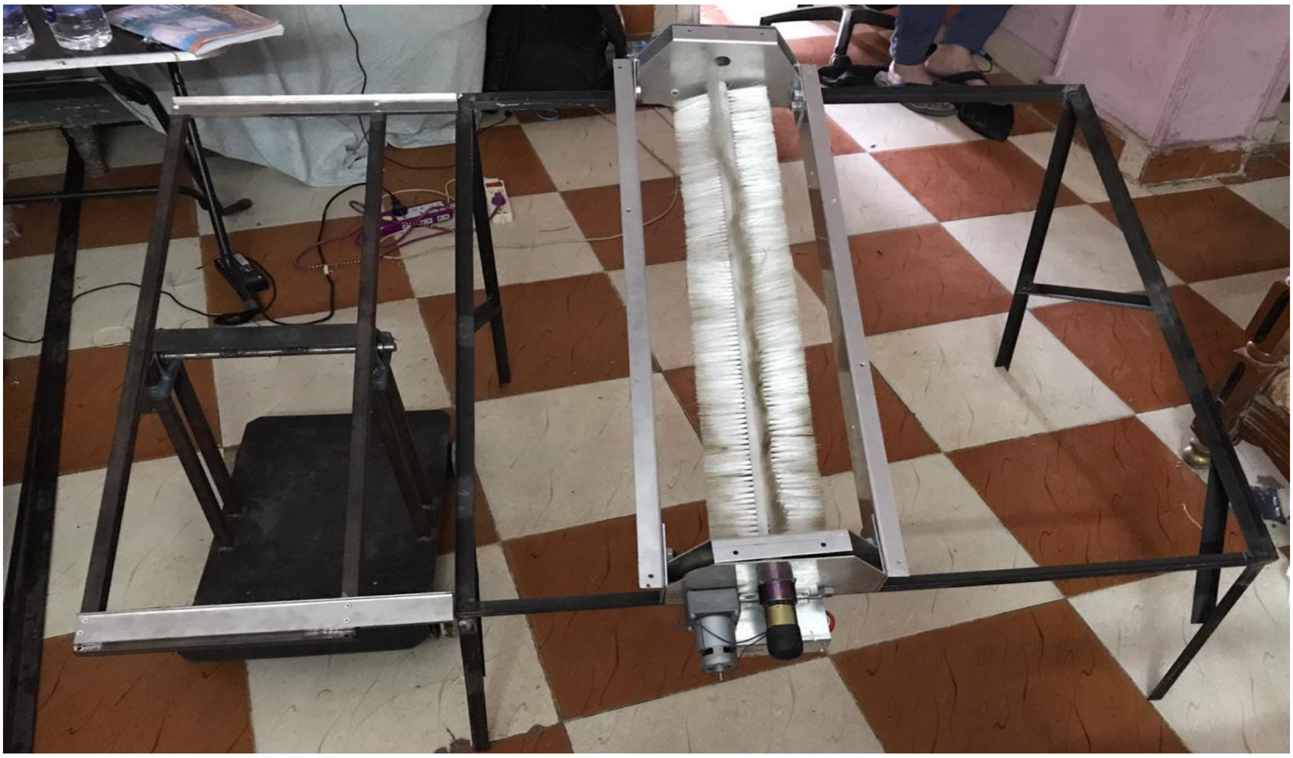


Fig 5-39 : Assembly project frame

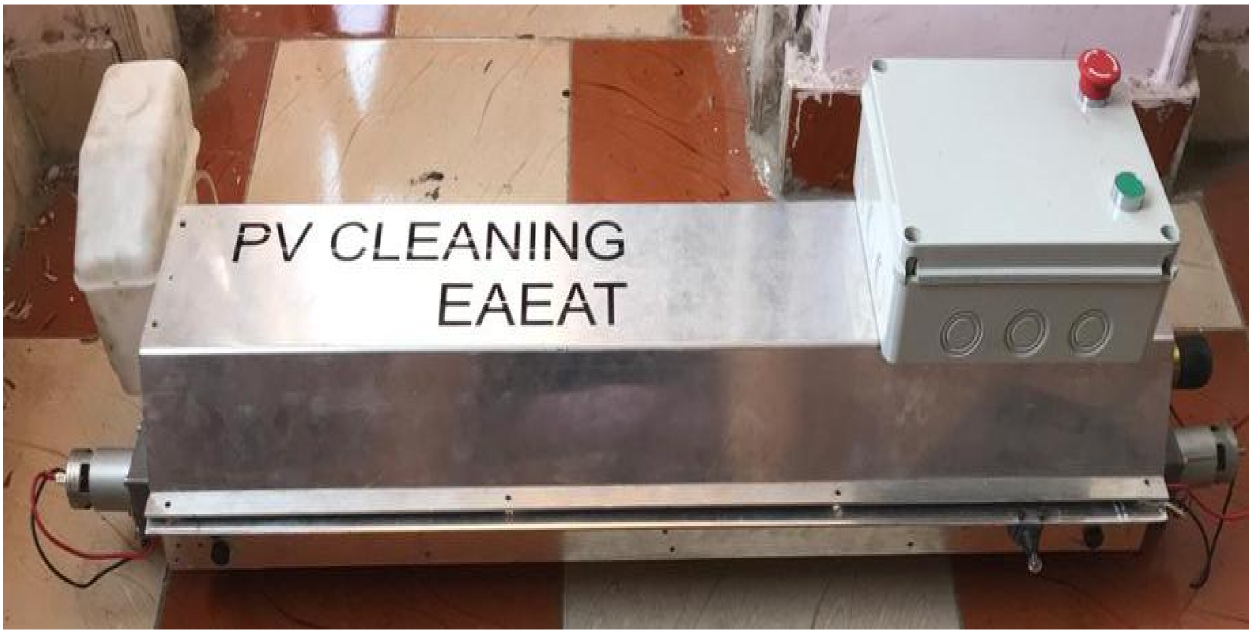


Fig 5-40 : Assembly Cleaning Robot

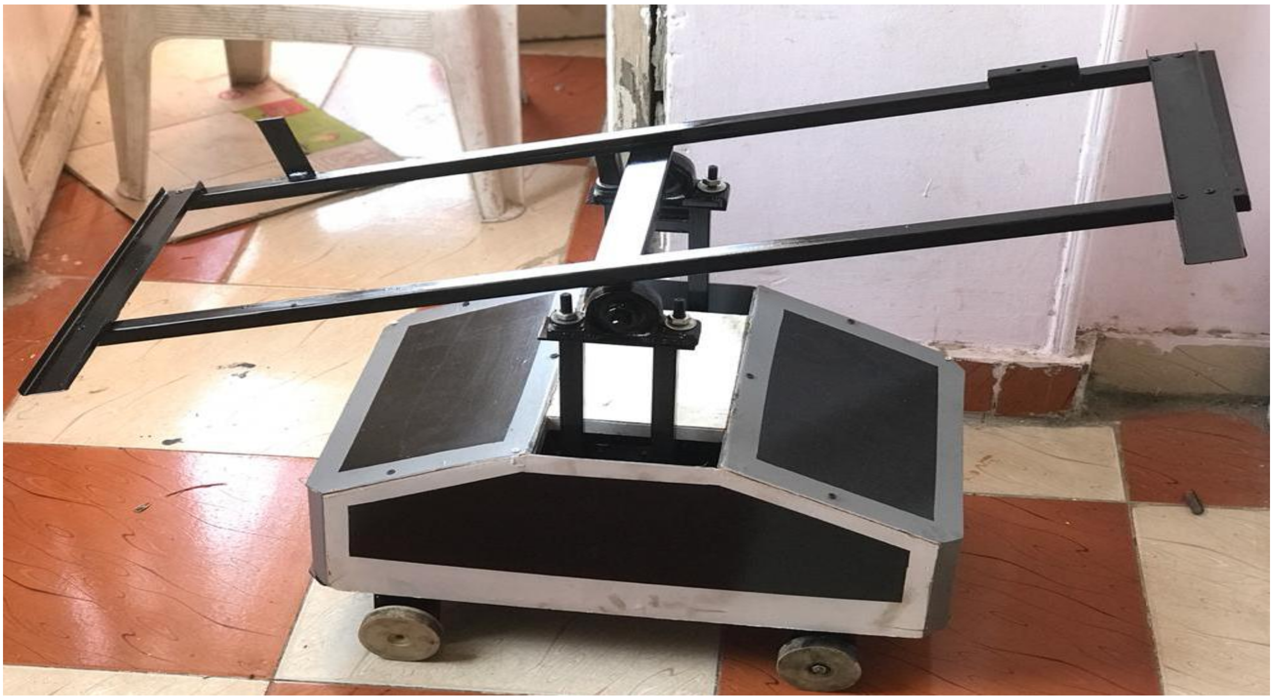


Fig 5-41 : Assembly Land Carriage

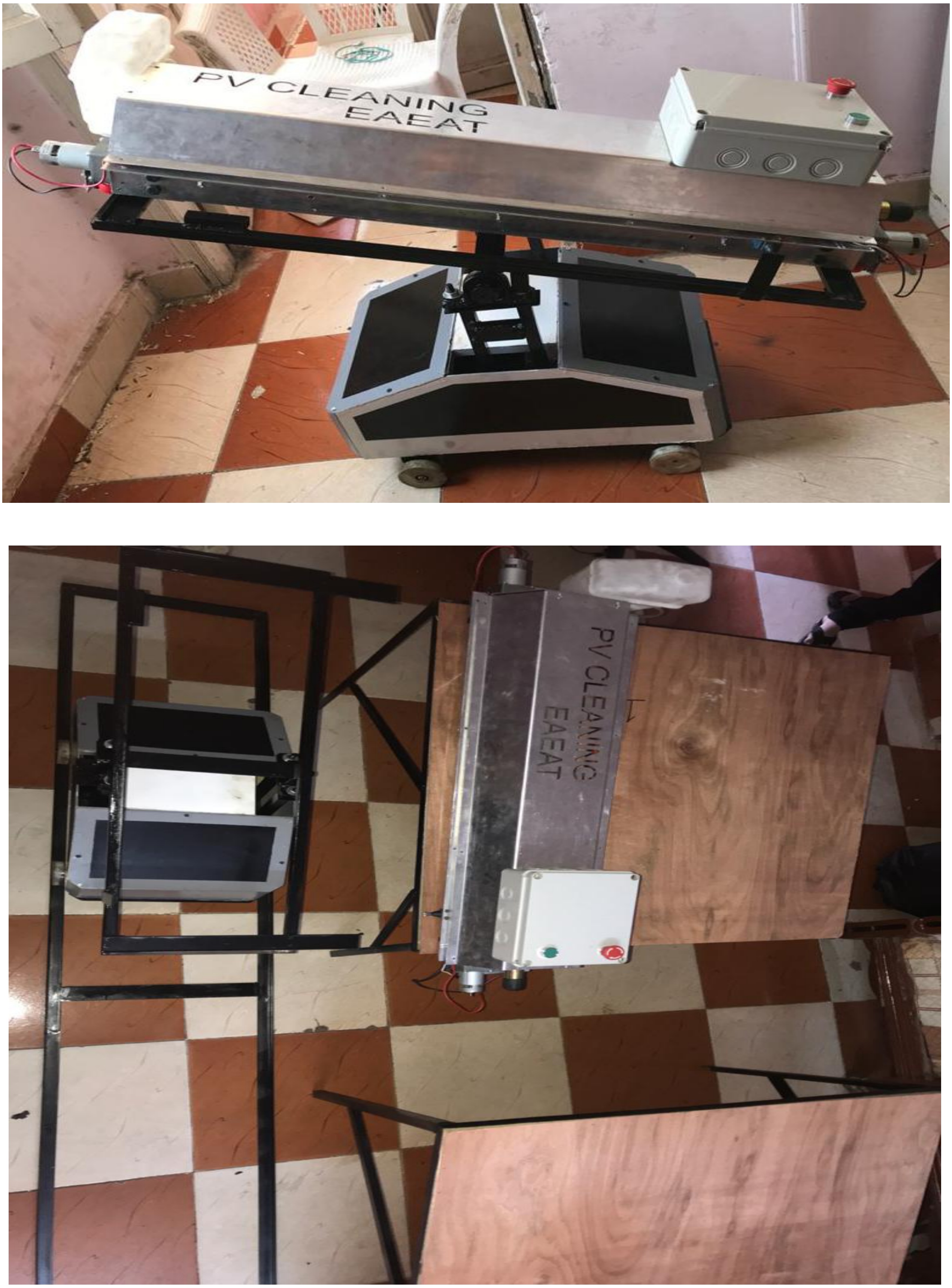


Fig 5-42 : Assembly of Project

Chapter 6

Conclusions & Future work

Chapter 6 : Conclusions & Future work

6.1 Conclusions

Automated solar panel PV cleaning system was designed and manufactured. Practical results showed that:-

1) Using automated system to clean solar panels to save labor and the annual continuous cost because the automatic system works for large periods of time up to 10 years without additional cost

2) Using appropriate materials has led to a reduction in the cost, as the price of the automatic system does not exceed $ 1,000

3) The efficient system of the automatic system provided a lot of waste solar energy as a result of the accumulation of dust and impurities that are difficult to slip.

4) Irrigation system attached to the cleaning system is characterized by preserving the amount of water and not wasting water due to the presence of the tank in the cleaning vehicle, thus not requiring a large amount of water and power

5) The application of the automatic system has led to a reduction in losses resulting from the human factor, as well as the provision of manpower

6) Using the appropriate material to form the brush led to a reduction in the weight of the brush and, consequently, to the weight of a cleaning carriage

7) automated PV cleaning system is provided by angle estimation system to setting the cleaning car in Solar panel which have different angles

6.2 Future work

1) By designing a connected system that draws energy for the project through solar panels attached to the project's systems and vehicles to optimize the nature of the climate and to provide the largest amount of energy

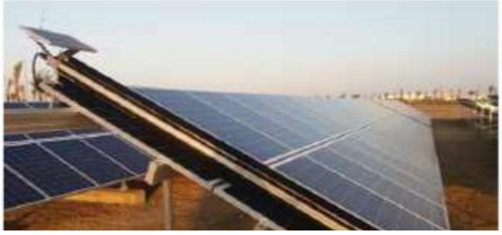


Fig 6-1 : Using Solar panel on Robot

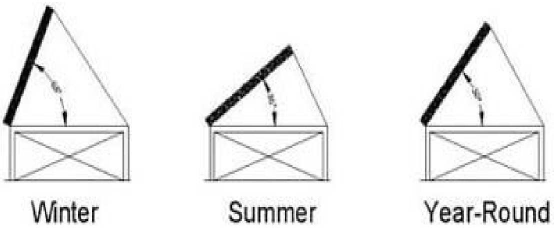
2) In the future development, there is a high-capacity ground-attached pump that works to save water through a suitable hose to pump water through the upper vehicle and clean the solar panels along the horizontal path.

3) Designing a water filtration system that cleans the solar panels, where the water coming out is collected again by water collectors, then it has been filtered and use them again to clean the panels, thus this led to the optimal use of water and reduced its consumption

4) Also, during future development, thermal sensors such as a thermal camera that takes different images along the path of the solar panels in the station are placed to determine which of the target panels to be cleaned as a result of a thermal increase due to the impurities attached to them.

5) Also, a mapping system was established, clarifying by taking many pictures of the placement area of the panels to determine the appropriate path and logarithmic priority to move the carriage to clean the solar panels in the least time possible and with appropriate transportation efficiency

6) By automating the orientation system and determining the angle of inclination of the solar panels appropriate to adjust the cleaner carriage holder to those solar panels have different Tendency



Suggesting for Improvement

we can add very interesting features in our system like de-ionized water cleaning; camera for inspection and climate based cleaning. And a tracking system at the panels to find out which panels you want to clean immediately. We can also make the system move through solar power instead of batteries in order to reduce the cost used and save energy.Also in future we can reduce the weight.

and can made compact design of the system with the help of booming technology.

Also now a day there is increase in use of solar system in industries as well as at homes, thus giving a bright future scope for this system.

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[2] "The Hashemite University" .(PV Panels cleaning robotics system). page ;62-75

[3] "Pablo Carrasco Zanini,Brian Parrott,", (Automated, robotic cleaning of solar panels), page ;44-55.

[4]' Yibo Zhang" (Self-cleaning surfaces for solar energy applications,), page ;143-162

[5] "Mazumder" (Electrodynamics removal of dust from solar panels) page ;123-132 and 332-353.

[6] "Dorobantu" (The effect of surface impurities on photovoltaic panels) page ;74-99 and 210-215.

[7]" Zorrilla-Casanova," (Analysis of dust losses in photovoltaic modules), page ;98-117 and 197-216.

[8]" Sulaiman, Shaharin A." (Effects of dust on the performance of PV panels.),, page ;212-223 and 303-314.

[9]" Kimber, A." (The effect of soiling on large grid-connected photovoltaic systems), page ;67-176 and 213-221.

[10]" Mavroidis " (Robotic device for cleaning photovolatic panel arrays,) page ;91-112

[11] " Boykiw, Elizabeth," (The effect of settling dust in the Arava valley on the performance of solar photovoltaic panels,).. page ;77-82 and 147-184

[12] (Solar Panel Maintenance),.At part of Westcoast Solar Energy, page ;73-122.

[13] (Residential Solar Panel Cleaning Systems),At part Heliotex,. page ;133-142 and 204-215

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[15]"Stephen Herman" (Industrial Motor Control Cengage Learning),,. page ;280-313

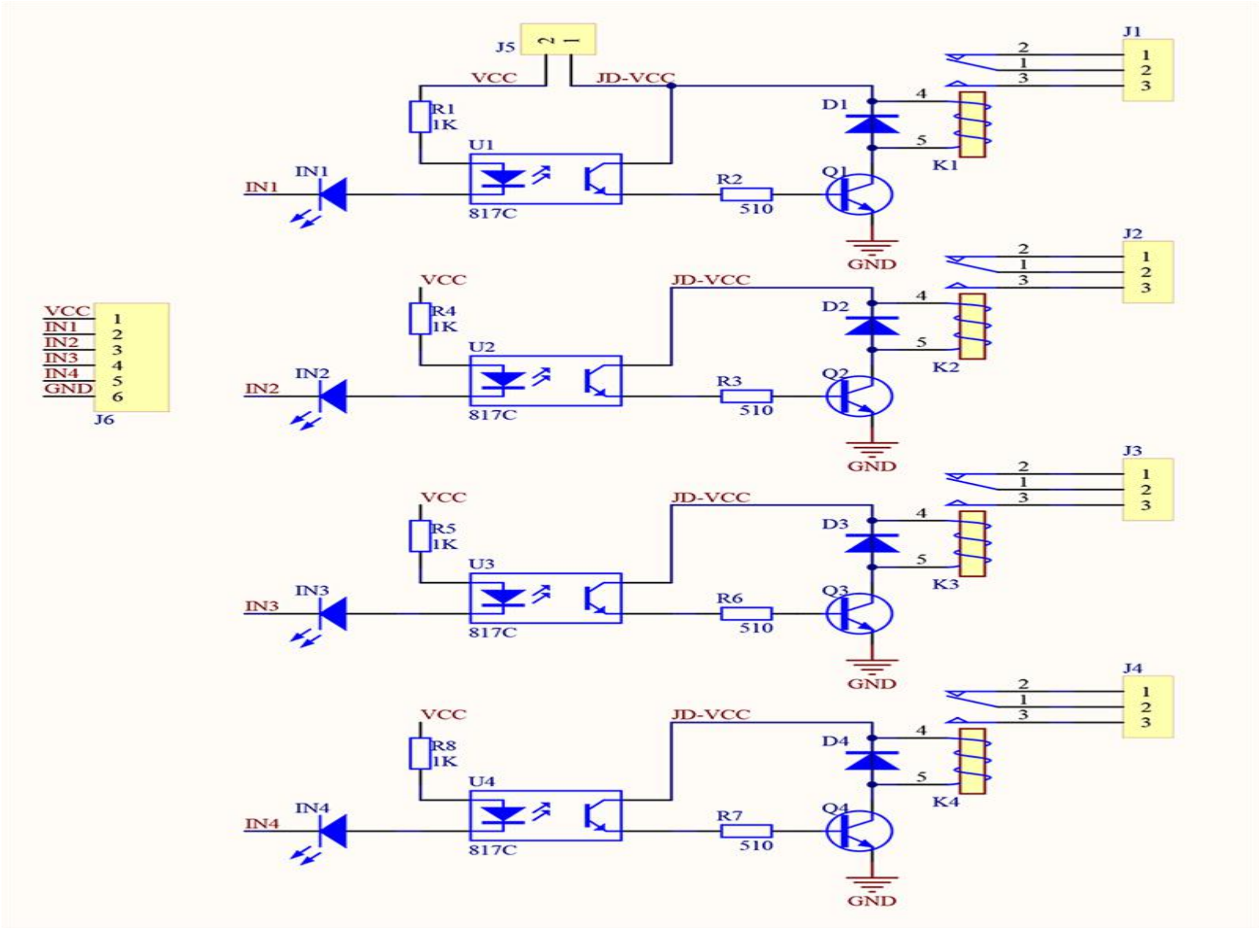
[16]" Munson,Young,Okiishi" (Fundamentals of Fluid Mechanics),.,sixth edition, page ;116-122

[17] "YUNUS,A.ÇENGEL",. (Fluid mechanics,fundamentals and applications page ;202-254

[18] "R.C Hibbeler,". PEARSON, (Mechanics for Engineers Statics) page ;186-215

Appendices

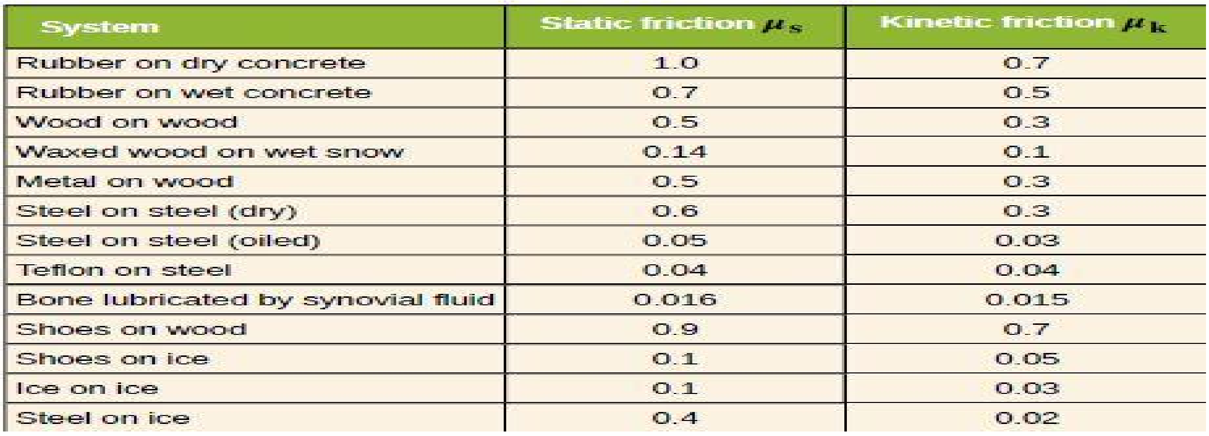
1) Relay Module 4 channel Data sheet



[15]

2) selection friction between materials Appendix

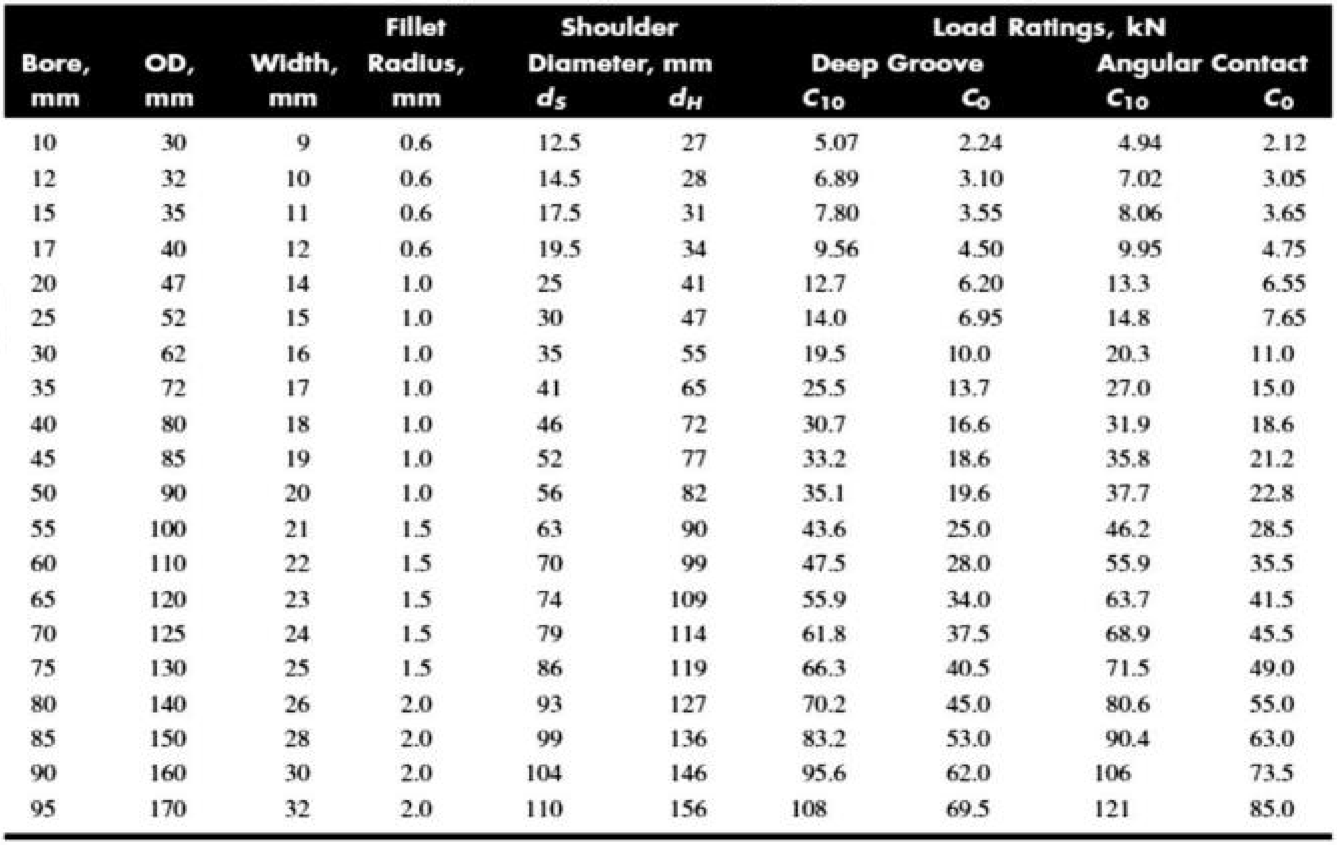
Table A1 selection friction



System	Static friction μ_s	Kinetic friction μ_k
Rubber on dry concrete	1.0	0.7
Rubber on wet concrete	0.7	0.5
Wood on wood	0.5	0.3
Waxed wood on wet snow	0.14	0.1
Metal on wood	0.5	0.3
Steel on steel (dry)	0.6	0.3
Steel on steel (oiled)	0.05	0.03
Teflon on steel	0.04	0.04
Bone lubricated by synovial fluid	0.016	0.015
Shoes on wood	0.9	0.7
Shoes on ice	0.1	0.05
Ice on ice	0.1	0.03
Steel on ice	0.4	0.02

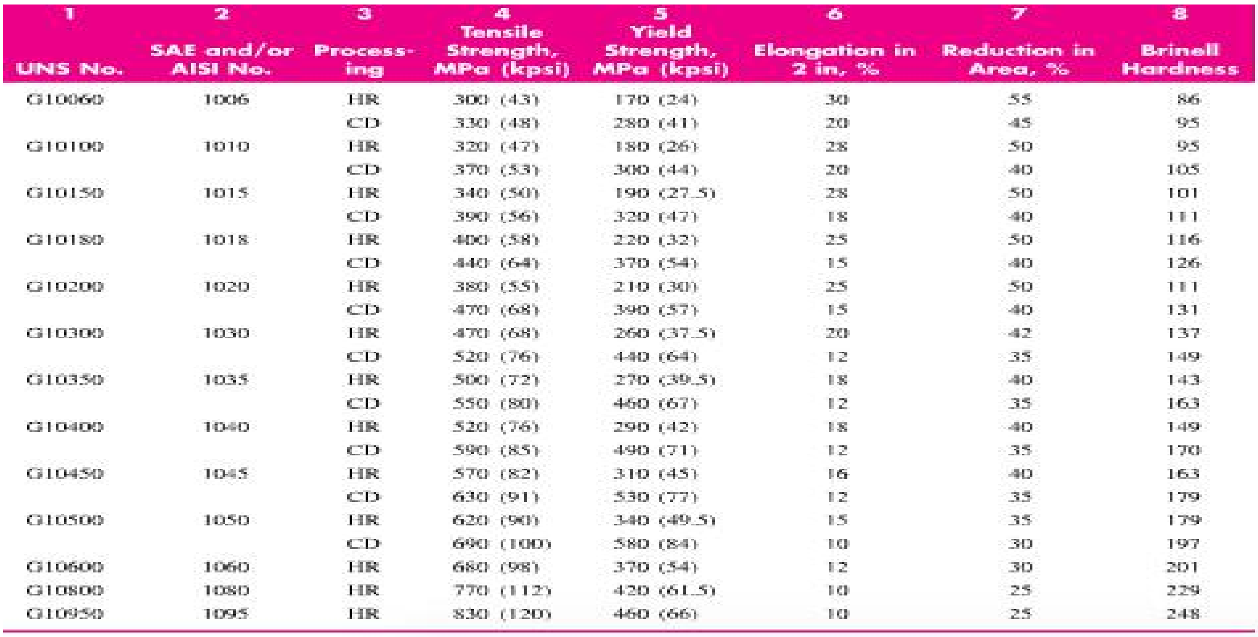
3) selection Bearing and shafts Appendix

Table A2 selection core for bearing



Bore, mm	OD, mm	Width, mm	Fillet Radius, mm	Shoulder Diameter, mm		Load Ratings, kN			
				d_S	d_H	Deep Groove C_{10}	C_0	Angular Contact C_{10}	C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0
85	150	28	2.0	99	136	83.2	53.0	90.4	63.0
90	160	30	2.0	104	146	95.6	62.0	106	73.5
95	170	32	2.0	110	156	108	69.5	121	85.0

Table A3 selection yield strength for shaft



1 UNS No.	2 SAE and/or AISI No.	3 Processing	4 Tensile Strength, MPa (kpsi)	5 Yield Strength, MPa (kpsi)	6 Elongation in 2 in, %	7 Reduction in Area, %	8 Brinell Hardness
G10060	1006	HR	300 (43)	170 (24)	30	55	86
		CD	330 (48)	280 (41)	20	45	95
G10100	1010	HR	320 (47)	180 (26)	28	50	95
		CD	370 (53)	300 (44)	20	40	105
G10150	1015	HR	340 (50)	190 (27.5)	28	50	101
		CD	390 (56)	320 (47)	18	40	111
G10180	1018	HR	400 (58)	220 (32)	25	50	116
		CD	440 (64)	370 (54)	15	40	126
G10200	1020	HR	380 (55)	210 (30)	25	50	111
		CD	470 (68)	390 (57)	15	40	131
G10300	1030	HR	470 (68)	260 (37.5)	20	42	137
		CD	520 (76)	440 (64)	12	35	149
G10350	1035	HR	500 (72)	270 (39.5)	18	40	143
		CD	550 (80)	460 (67)	12	35	163
G10400	1040	HR	520 (76)	290 (42)	18	40	149
		CD	590 (85)	490 (71)	12	35	170
G10450	1045	HR	570 (82)	310 (45)	16	40	163
		CD	630 (91)	530 (77)	12	35	179
G10500	1050	HR	620 (90)	340 (49.5)	15	35	179
		CD	690 (100)	580 (84)	10	30	197
G10600	1060	HR	680 (98)	370 (54)	12	30	201
G10800	1080	HR	770 (112)	420 (61.5)	10	25	229
G10950	1095	HR	830 (120)	460 (66)	10	25	248

4) Factors

Table A4 specify Cm and Ct for shaft

	Loading condition	C_m	C_t
Stationary shafts	Load gradually applied	1.0	1.0
	Load suddenly applied	1.5 – 2.0	1.5 – 2.0
Rotating shafts	Load gradually applied	1.5	1.0
	Load suddenly applied (Minor shock)	1.5 – 2.0	1.0 – 1.5
	Load suddenly applied (Heavy shock)	2.0 – 3.0	1.5 – 3.0

Table A5 specify af for bearing

Type of Application	Load Factor
Precision gearing	1.0–1.1
Commercial gearing	1.1–1.3
Applications with poor bearing seals	1.2
Machinery with no impact	1.0–1.2
Machinery with light impact	1.2–1.5
Machinery with moderate impact	1.5–3.0

Drawing sheet :-

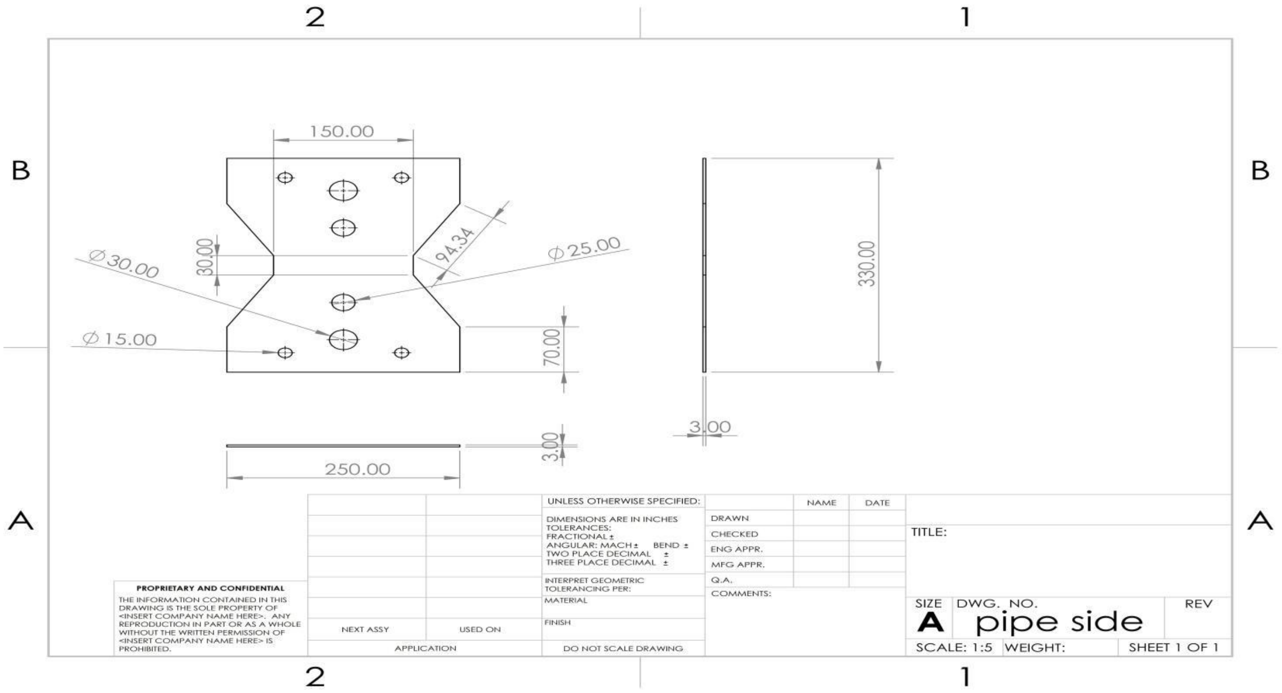


Fig A1: sample sheet for Pipe side

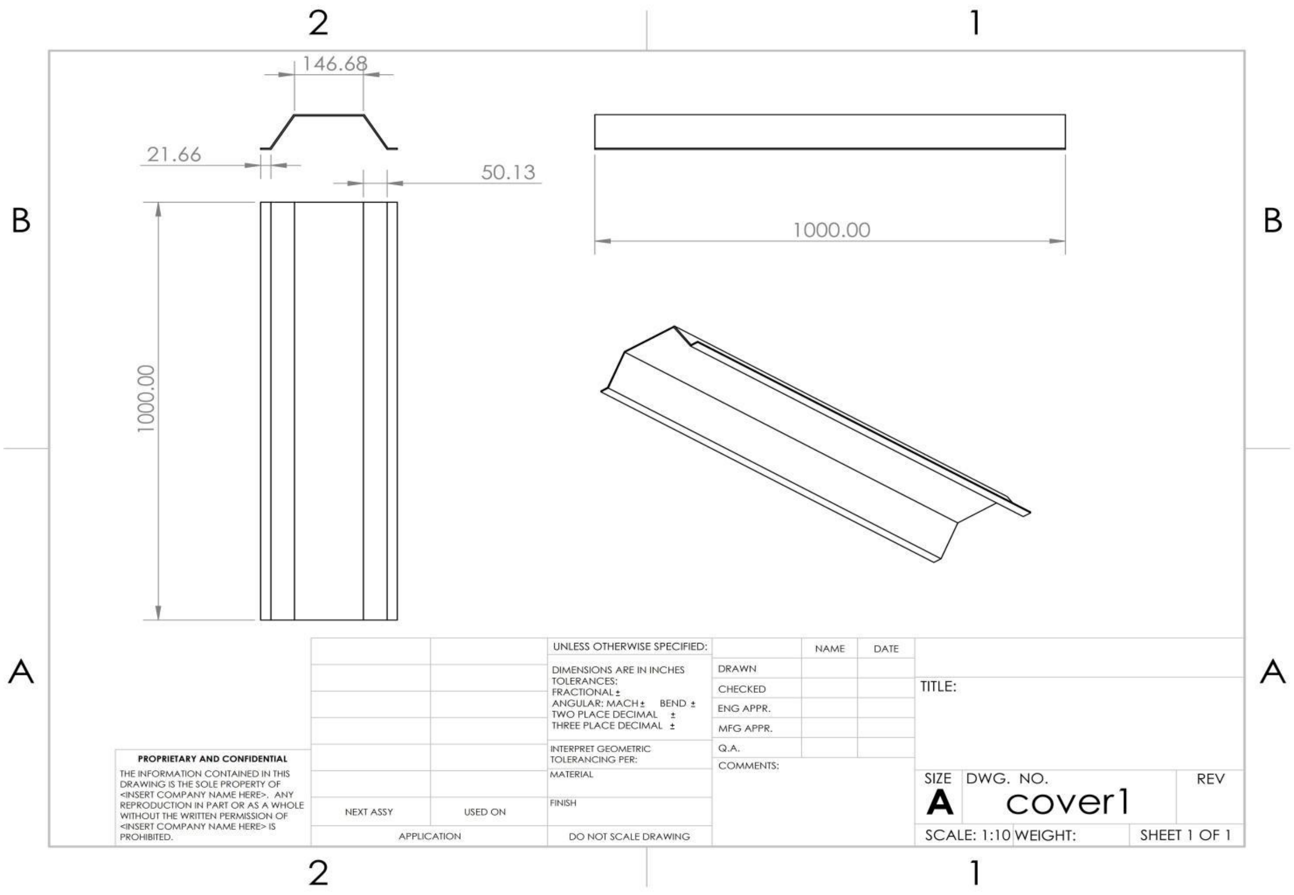


Fig A2 : sample sheet for cover

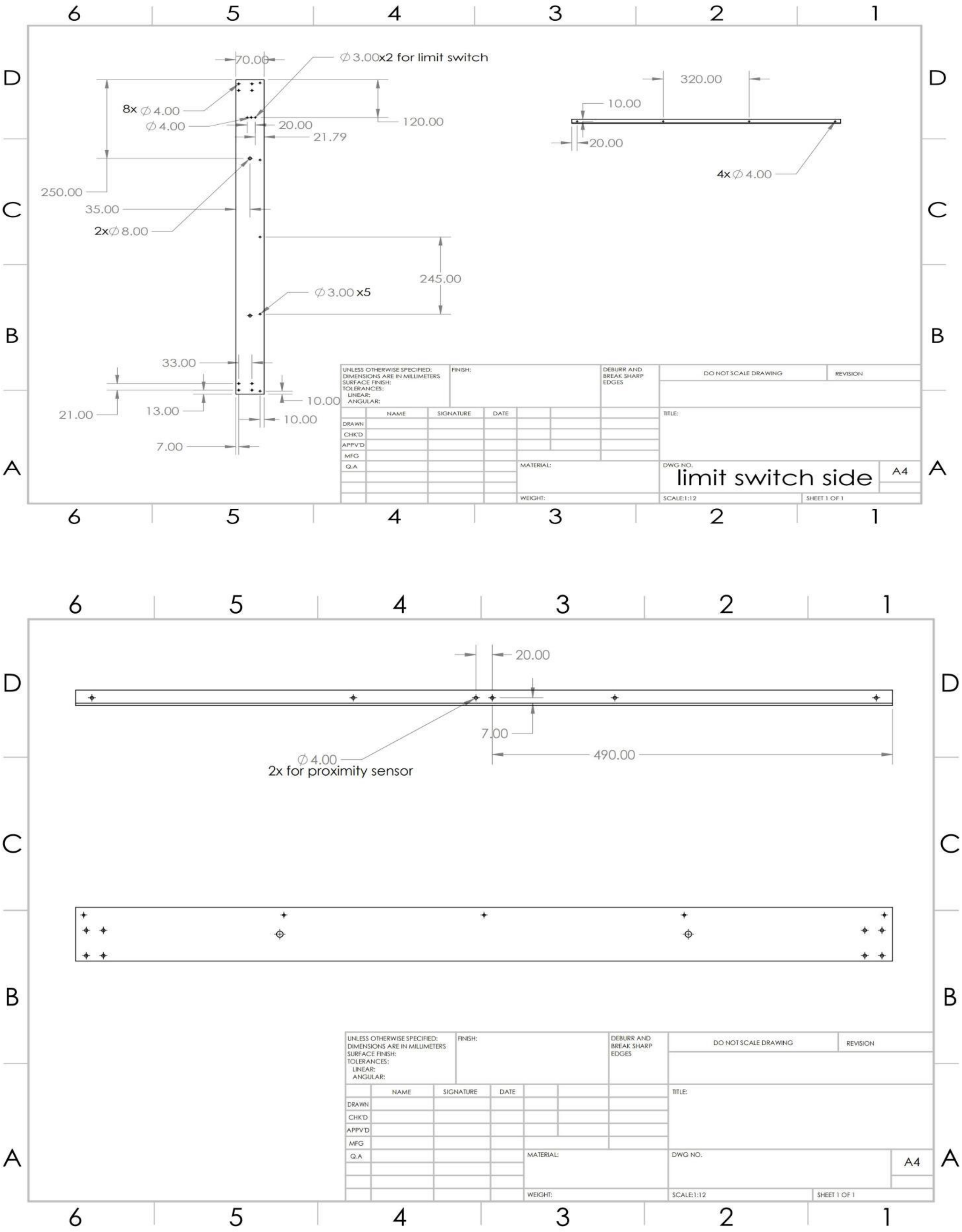


Fig A3 : sample sheet for front Side

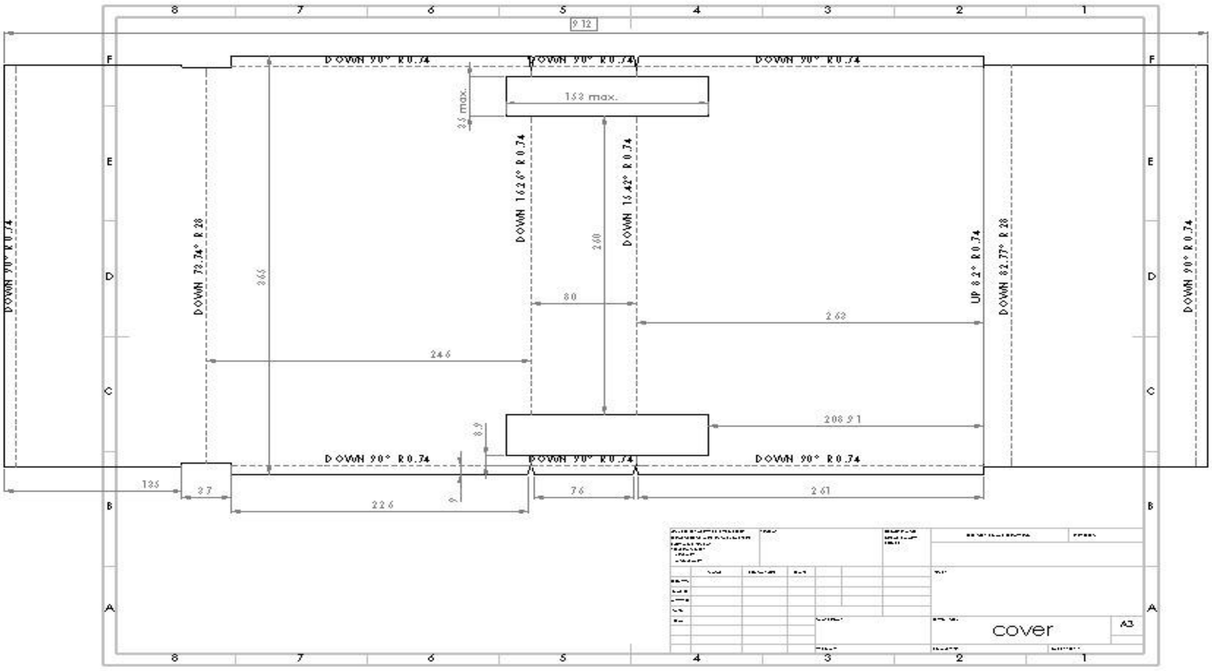


Fig A4 : sample sheet for cover

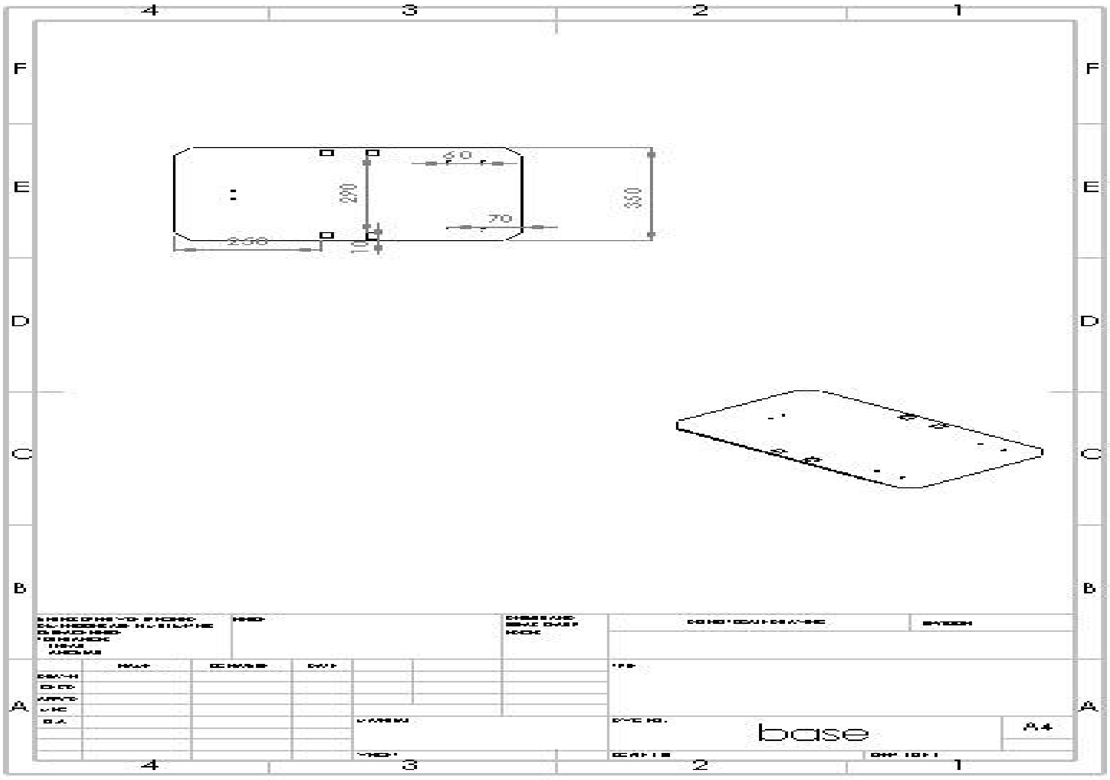


Fig A5 : sample sheet for base

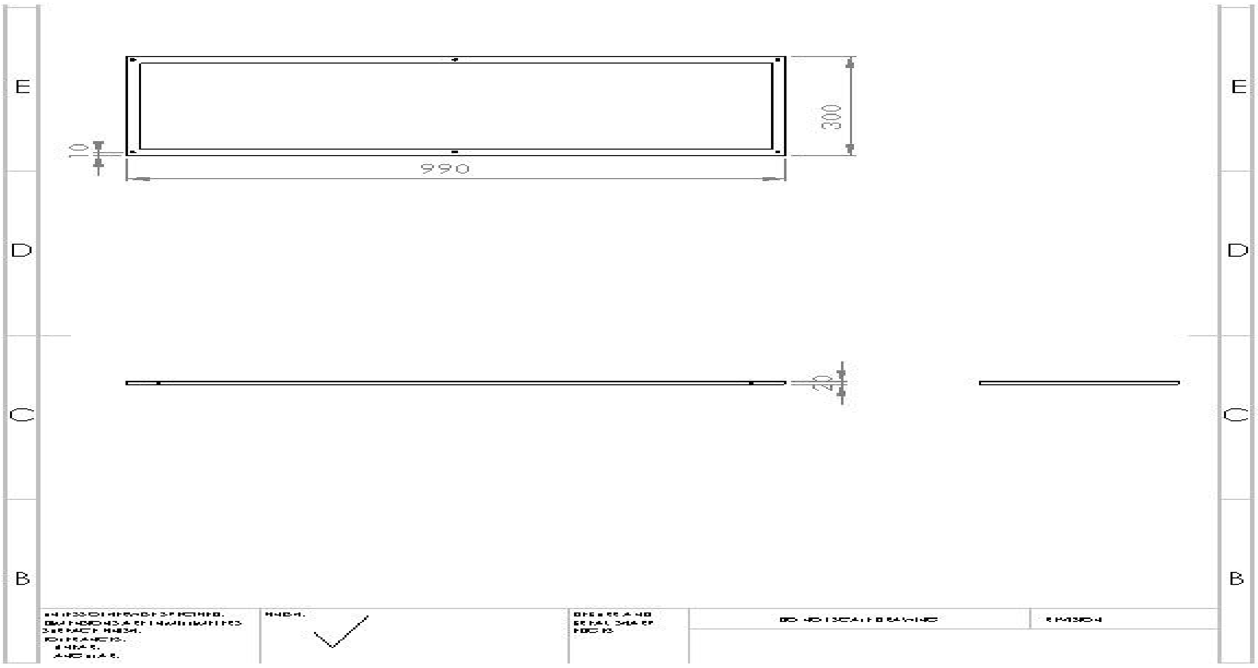


Fig A6 : sample sheet for Table

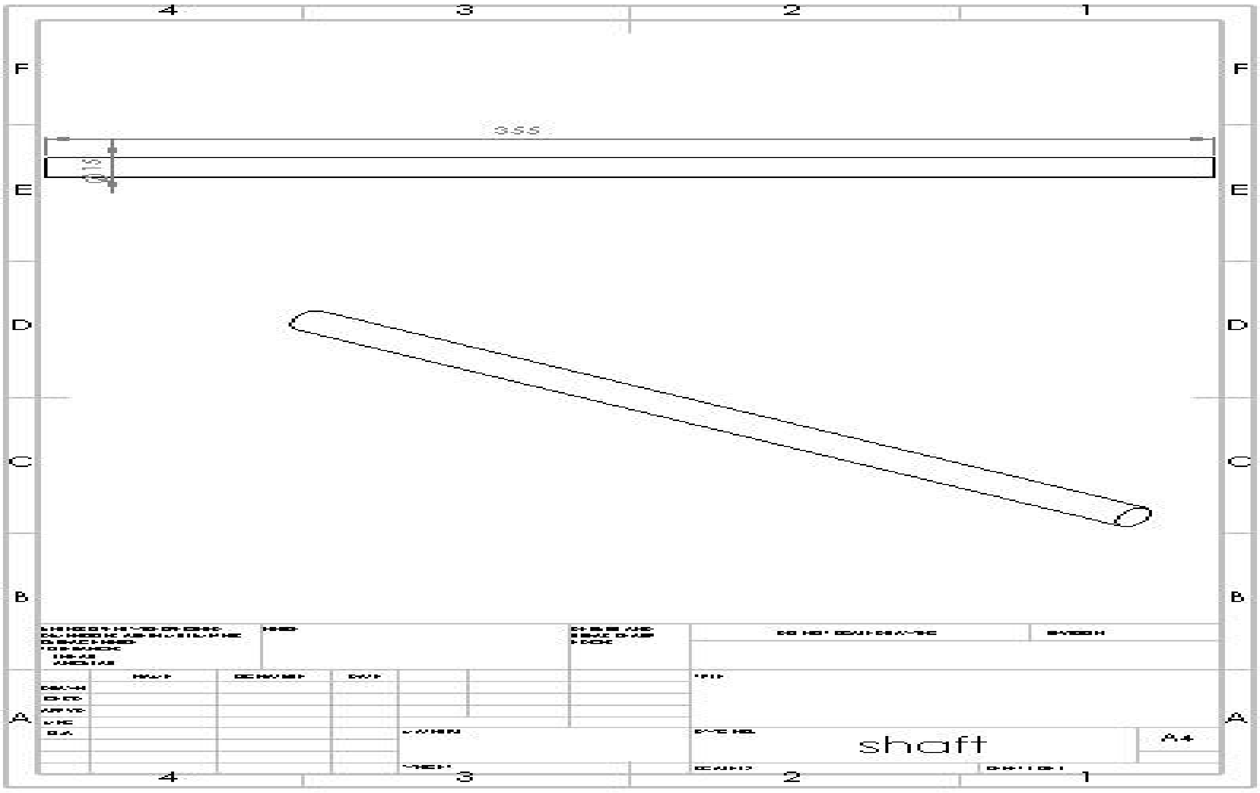


Fig A7 : sample sheet for Shaft

المقدمة :-

يتمثل الهدف الرئيسي لنظام تنظيف الألواح الشمسية في حل مشكلة الشوائب التي يمكن أن تتكون على شكل غبار و ورق والنفايات التي يمكن أن تتراكم على سطح الألواح الضوئية. لذلك ، يعد تنظيف الألواح الشمسية ضروريًا لضمان الكفاءة الأمثل وإنتاج الطاقة الأقصى

الهدف الرئيسي من هذا المشروع هو تحسين أداء المحطات الشمسية [1]

المشكلة فى توفير كفاءة النظام الكهروضوئي لأن الأتربة على الوحدات الكهروضوئية في هذه المنطقة المعرضة للغبار تمثل مشكلة كبيرة لأنها تؤدى الى تقيلل من كمية الطاقة وحتى تقلل من عمر الألواح والمكونات الأخرى في النظام الكهروضوئي . [1]

يزال هناك الكثير من الموارد المتاحة في الشرق الأوسط وخاصة مصر للاستثمار في الطاقة المتجددة في المستقبل. نظرًا لأن معظم الأراضي في مصر عبارة عن صحراء رملية بها الكثير من الإشعاع الشمسي ، فإنه يتضح إلى أن هناك إمكانات كبيرة لإنشاء منشآت الطاقة الشمسية الكهروضوئية في المنطقة وتلبية احتياجات الطاقة المستقبلية. [2]

يختلف الإشعاع الشمسي على اللوح الشمسى حسب الموقع الجغرافي والوقت واتجاه اللوحة حول الشمس والسماء.

وان الاستفادة القصوى للكفاءة للألواح الشمسية تتمثل فى المداومة على تنظيفها وابعاد عنها الأتربة والمتراكمات المختلفة من خلال نظام فعال وهذا يتمثل فى منظومة التنظيف الاوتماتيكى لالواح الطاقة الشمسية التى تقوم بها [2]

الخلاصة:-

الهدف من مشروعنا هو تصميم نظام اوتماتيكى لتنظيف الألواح الشمسية والذي يمكننا من خلاله تجنب التأثير السيئ للتلوث على خلايا الألواح الشمسية الكهروضوئية. وعلى وجه الخصوص ، نحتاج إلى تقليل الخسارة والاستهلاك السنوي للطاقة الطاقة لتكون حوالى 10٪ (من خلال التخلص على أسباب فقدان الطاقة

من الغبار المتراكم والذى اتضح في الدراسات الكهروضوئية للوحة الشمسية على انه يؤثر على الأداء والشفافية

دراسة الكفاءة الكهروضوئية في الألواح الشمسية بالقرب من مدينة القاهرة في مصر. تشير النتائج إلى انخفاض بنسبة 18٪ في ناتج الطاقة الذي لوحظ خلال الظروف الخارجية لحقل العمل في الهواء الطلق انه يقترب من 40٪ في السنة دون حلول التنظيف

هذا يقلل من كمية الضوء التي تصل إلى اللوحة ويقلل من ناتجها لذلك يجب علينا تنظيف الألواح الشمسية الكهروضوئية للحصول على فائدة كبيرة وزيادة الناتج والربح

الأكاديمية المصرية للهندسة والتكنولوجيا المتقدمة التابعة لوزارة الأنتاج الحربى

قسم الميكاترونكس

[نظام التنظيف الأوتوماتيكى لألواح الطاقة الشمسية]

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م/ مصطفى محمود

[2019-
2020]

[نظام التنظيف الأوتوماتيكى لألواح الطاقة الشمسية]

للحصول على الكفاءة عالية >>

[مشروع التخرج فى الاكاديمية المصرية للهندسة والتكنولوجيا المتقدمة ويكمن الهدف من تنفيذ المشروع فى الحصول على ألواح طاقة شمسية ذات كفاءة عالية من خلال توفير التنظيف المستمر والمناسب وبالتالى التخلص من الأتربة والشوائب المتراكمة على الألواح والتى تتسبب فى فقد الطاقة]

[اغسطس]
[2020]